RED ABALONE MARKET FISHERY OPERATING GUIDELINES

California Abalone Association
October 2009

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

ACKNOWLEDGEMENTS

The California Abalone Association wishes to acknowledge the following groups and individuals who assisted us in this endeavor. We are grateful for the help we received and the opportunity to work with these bright, motivated, and visionary people.

California Center for Cooperative Development
Kim Coontz and Luis Sierra

California Department of Fish and Game
Tom Barnes, Kai Lampson, Sonke Mastrup, Derek Stein, Ian Taniguchi,
Marija Vojkovich, John Ugoretz

California Fish and Game Commission – Marine Resources Committee
Richard Rogers, Michael Sutton, Craig Shuman

Ray Hilborn

Ken Manock

Patagonia

Jeremy Prince

SMI Abalone Advisory Group
Jessie Altstatt, Bill Bernard, John Butler, Daniel Geiger, Sean Hastings, Terry Maas,
Chris Mobley, Greg Sanders

Steve Rebuck

Review Committee
Doug Butterworth, Harry Gorfine, Steve Schroeter, Ed Weber

Joseph Sullivan

Sustainable Fisheries Fund
Mike Eaton and Andy Reid

Sustainable Fisheries Group
Chuck Cook, Steve Gaines, Jocelyn Ondre, Michael Robinson

Robert Treanor

ACKNOWLEDGEMENTS

University of California at Santa Barbara
Bren School of Environmental Science & Management
Kristen Bor, Chris Costello, Heather Hodges, Ariel Jacobs, Hunter Lenihan,
John Melack, Dan Ovando, Sarah Rathbone, Josh Uecker, Sarah Valencia

World Wildlife Foundation
Alison Cross and Meredith Lopuch

GUIDELINE AUTHORS

These guidelines were developed by members of the California Abalone Association. The authors listed below represent a cumulative total of more than 350 years of diving experience, much of it at San Miguel Island.

Chris Voss, President
Harry Liquornik, Vice President
John Woodcock, Secretary
Craig Brooker, Treasurer
Jim Marshall, Technical Advisor

Additional support and guidance was provided by: Jeff Baldwin, Mark Brubaker, Michael Candy, Pierre Charest, Bob Duncan, Michael Harrington, Mike Kitahara, Gaylord Parkinson, Richard Pogre, Mike Radon, and Don Thompson

Administrative support was provided by Alicia Bonnette

Photos by Jody Helzer Pesapane of Liquid Blue Media

I. INTRODUCTION

Modern fishery management is not simply about science, it also requires fishermen to manage themselves and have a framework for doing so. By controlling their activities fishermen can avoid adding more strain on the valuable wild abalone populations of California. Fishermen need to be directly involved in resource management processes so they have a stake in resource stewardship and are encouraged to become guardians of that resource. Thus, their involvement completes an otherwise incomplete conservation equation.

The California market abalone fishery has been and continues to be a leader in innovative resource management. This fishery was the first in the State to set size limits and restrict access. Presently, the California market sector is striving to utilize tools that incorporate modern, successful, and cutting edge resource management principles which place fishery sustainability above all else.

II. GUIDING PRINCIPALS

The framework for the principles expressed in these Operating Guidelines is based on four (4) components:

<u>First</u>: The "California Marine Life Management Act" (MLMA), which became law on January 1, 1998, placed greater responsibility for marine fisheries on the California Fish and Game Commission (Commission) and the California Department of Fish and Game (CDFG). The MLMA places priority on long-term benefits and sustainability over short-term benefits and emphasizes an ecosystem perspective. It also places a strong emphasis on a science-based management plan that is developed by the combined efforts of knowledgeable fishermen, whose livelihood depends on a healthy resource, and marine biologists.

<u>Second</u>: "The Barefoot Ecologist's Toolbox", Jeremy Prince, Ph.D. (2003), acknowledges the spatial complexities of marine resource management and recognizes the invaluable knowledge of fishery participants about their fishery. These credentials include fishery history, culture, and environment; and are often discounted when assessing a resource. Both Dr. Prince and Dr. Ray Hilborn (Professor of Fisheries Management, University of Washington, Member of President's Commission for Ocean Policy) have demonstrated great success in fishery management, recovery, and enhancement by developing studies that tap into, train, and utilize the fishermen. Implementing a Barefoot Ecology program for San Miguel Island (SMI) red abalone (Haliotis rufescens) will involve fishermen who have extensive knowledge of that resource. Their strong stake in the preservation of this resource will foster stewardship for the sustainability of the resource.

Third: The Commission policy on "*Restricted Access Commercial Fisheries*" (Appendix A) is a valuable reference. In general, the goals of the restricted access policy are to enhance the State's ability to manage its commercial fishery resources and contribute to sustainable fisheries management by:

1. Providing a means to match the level of effort in a fishery to the status of fishery resources
2. Promoting a sustainable fishery and giving fishery participants a greater responsibility for maintaining sustainability
3. Providing a mechanism for funding fishery management, research, monitoring, and law enforcement activities
4. Maintaining long-term economic viability in a fishery and providing long-term social and economic benefits to the State and fishery participants
5. Providing for an orderly fishery and expanding opportunities for the market sector to share management responsibility with CDFG

Fourth: The "Abalone Recovery Management Plan" (ARMP) adopted by the California Fish and Game Commission in December 2005 provides a framework for the recovery and management of California abalone populations. This recovery and management plan was developed to manage abalone fisheries and prevent further population declines throughout California, and to ensure that current and future populations will be sustainable. Section 7.38 (Alternative 8) of the ARMP allows for a limited abalone fishery at selected areas at a reduced density prior to full recovery in all areas (Appendix B).

III. Background

In 1997 legislation created a moratorium for the taking of abalone in the waters south of San Francisco. It also mandated the creation of the Abalone Recovery and Management Plan (ARMP) to provide a cohesive framework for the future management of abalone fisheries. In December 2005, the Abalone Recovery and Management Plan (ARMP) was adopted by the California Fish and Game Commission (Commission).

A. San Miguel Island Abalone Fishery Advisory Group (AAG)

In January 2006, the California Department of Fish and Game (CDFG) embarked on a "limited abalone fishery" management and monitoring process by forming the "San Miguel Island Limited Fishery Task Team". This group consisted of CDFG staff and representatives from the California Abalone Association (CAA). Their mission included:

1. The development of a scientifically sound survey program
2. Creating a framework for integrating CDFG and fishermen in survey and management efforts
3. Developing parameters for a fishery

In March 2006, the Commission directed CDFG to initiate a more formal process to consider the limited abalone fishery at SMI. This led to an extensive cooperative planning approach and constituents to an advisory group called the "San Miguel Island Abalone Fishery Advisory Group" (AAG) were selected. In September 2006, the AAG stakeholders from commercial fishing (CAA), recreational diving, fisheries science, and marine conservation groups, as well as the Channel Islands Marine Sanctuary, Channel Islands National Park, and CDFG began meeting. Their mission was "to provide a limited range of fully developed alternatives for managing a potential fishery at SMI to CDFG."

The AAG stakeholders are slated to complete their charge in November 2009 and finalize four (4) different management alternatives for a potential fishery at SMI. These alternatives will be prepared by the following AAG constituent groups:

1. Commercial fishing
2. Recreational diving
3. Conservation
4. Preservation

Each alternative will include recommendations on:

1. Total Allowable Catch (TAC),
2. Allocation between commercial and recreational take
3. Regulations to achieve TAC and allocation
4. Management, enforcement, and monitoring considerations

The CDFG will subsequently consider each of these proposed management alternatives in developing their recommendations to the Commission. The Commission will be asked to study these Alternatives in preparation for discussions in February 2010 on whether or not to reopen the SMI red abalone fishery.

B. California Abalone Association (CAA)

The California Abalone Association (CAA) was formed in 1971 and has been an active participant in abalone fisheries management for 38 years. The CAA has held a 501(c) (3) non-profit status since 1984 and is based in Santa Barbara California.

The CAA mission is "to restore and steward a market abalone fishery in California that utilizes modern management concepts, protects and enhances the resource, and guarantees a sustainable resource for the future."

In June 2006, the CAA presented CDFG with the "San Miguel Island Restricted Access Abalone Fishery Market Sector Plan" which captured the principals embraced by CAA members. Over the next several years these principals were further developed and expanded. In April 2009, the CAA presented the Fish and Game Marine Resources Committee with the "Red Abalone Market Fishery Operating Guidelines" (Guidelines) that embrace the four (4) guiding principles previously described.

The Guidelines expand upon traditional government approaches to public and stakeholder involvement to create an adaptive shared management framework that establishes a community based monitoring, harvesting, and marketing cooperative. This cooperative will be responsible to the State for management of the harvest and harvesters.

It is hoped that these Guidelines will be the framework for sustainably harvesting red abalone and merit a "certification of sustainability" from the Marine Stewardship Council (MSC). The MSC is an independent, non-profit organization with internationally recognized environmental standards for sustainable and well-managed fisheries. Their certification label identifies a product which originates from a responsibly managed fishery.

In October 2009, the CAA began the MSC pre-assessment process to identify strengths and weaknesses in the CAA's proposed fishery management Alternative. Scientific Certification Systems (SCS) has been retained to conduct the pre-assessment. Their report "*INSERT REPORT NAME HERE*" (Appendix C) will also be used to determine potential barriers to certification and whether a reopened red abalone fishery could progress to a full MSC assessment stage.

The MSC pre-assessment will complement a stock evaluation that is currently being conducted by the Bren School of Environmental Science and Management at the University of California at Santa Barbara. The Bren School evaluation will analyze potential fishery impacts and assess the effectiveness of the CAA's proposed management alternative. This evaluation will help determine whether the proposed management approach is precautionary enough to allow continued recovery of SMI red abalone populations.

In addition, the CAA is currently working with the Bren School on the "Optimal Design and Management of a Commercial Fishing Cooperative for the San Miguel Island Red Abalone Fishery" (Appendix D). Five (5) masters students and faculty sponsor Dr. Chris Costello will complete the group project. The project evaluates the viability of a self-funded commercial red abalone fishing cooperative, while providing recommendations to the CAA for managing the cooperative in a way that provides optimal environmental and economic benefits. If the fishery is reopened, the CAA will also work with the California Center for Cooperative Development (CCCD) and their partners to implement the cooperative's legal structure and help develop the educational and technical assistance essential to create a harvesting, monitoring, and marketing cooperative of abalone fishermen.

C. CAA Accomplishments

In 1991, the CAA initiated legislation that established the "Abalone Resource Restoration and Enhancement Dedicated Account". The purpose of this "Dedicated Account" is to fund abalone enhancement and research projects in California. Expenditures from the account are made by CDFG with guidance from the Commercial Abalone Advisory Committee (CAAC).

In 2006, 2007, and 2008 CAA members participated with other stakeholders (NOAA, National Parks, ReefCheck, CDFG, etc.) and contributed funding for surveys at SMI. In 2006, 400 transects were sampled at 202 random survey stations, and 5,695 abalone were counted. The results of this survey provided the first extensive data on SMI abalone densities, distribution, size, health, population estimates, and habitat characteristics since closure of the commercial abalone fishery in 1997. During the 2007 survey, 256 transects were sampled at 128 random survey stations, and 3,488 abalone were counted. The results for this survey data are still in draft form. In 2008, 350 transects were sampled at 175 random survey stations, and 6,470 abalone were counted. The results for this survey are being compiled and all three years of data will be compared. The planning for the 2009 surveys is underway and that event will take place from October 20 to 22. The 2009 surveys will be take place in areas that could support a fishery using zones selected and sized to detect change.

2008 Survey Transect Line

Along with the public/private partnership developed with CDFG the CAA has successfully collaborated with University of California (UC) researchers, the CAAC, and the AAG on the following projects:

1. Testing materials and methods for "outplanting" larval stage red abalone (UC Santa Barbara)
2. Restocking of juvenile red abalone (UC Santa Cruz)
3. Investigation of micro-predators of larval red abalone (UC Santa Barbara)
4. Installation of a permanent National Park Service Kelp Forest Monitoring site at SMI through a grant to the CAA from the Santa Barbara Energy Division Fishery Enhancement Fund
5. Development of abalone monitoring protocols in collaboration with CDFG (2006, 2007, 2008, and 2009)
6. Initiation of a two day workshop on abalone data needs, population modeling, harvest strategies, and potential fishery controls (December 2006)

7. Hiring Dr. Yan Jiao, from Virginia Polytechnic Institute, to model Total Allowable Catch (TAC) options for red abalone at SMI (2008)
8. Completion of a two day scientific review to evaluate the red abalone stock assessment in support of AAG deliberations funded by the Sustainable Fisheries Fund (February 2009)
9. Collaborated with CDFG on the installation of study sites at SMI to detect movement and growth at Tyler Bight and Judith Rock Reserve (2009)

D. CAA Goals and Objectives

The primary goal of the CAA is to advocate rational management for the protection, preservation, enhancement, and promotion of abalone. The CAA is committed to:

1. Actively rebuilding abalone populations
2. Developing science based fishery management to prevent overfishing
3. Identifying and finding solutions for wasteful or damaging practices that negatively impact California abalone populations
4. Assisting local, regional, state and federal authorities in enacting approaches, guidelines, programs, and laws that ensure the sustainability of the resource

The primary objectives of the CAA are to:

1. Develop a market abalone fishery that uses a monitoring, harvesting, and marketing cooperative to avoid the "tragedy of commons"
2. Work with the California Department of Fish and Game in acquiring data needed to evaluate fishery impacts on the abalone resource and develop accurate annual stock assessments
3. Utilize timely adaptive management techniques that respond to changes in fishery conditions to maintain a viable red abalone population, and sustain the fishery

The introduction of the "Guide to California's Marine Life Management Act" (1998) states, "The effectiveness of management measures depends greatly upon public confidence in the way decisions are made and put into practice. Critical to building and maintaining this confidence is openness in decision making that goes beyond traditional, formal processes."

Therefore, the components outlined in these Guidelines are set forth to:

1. Expand upon traditional government approaches to public and stakeholder involvement to establish a framework for adaptive shared management
2. Outline the process to establish a community based monitoring, harvesting, and marketing cooperative that will be responsible to the State for management of the harvest and the harvesters
3. Meet the challenge of sustaining the abalone resource
4. Provide the basis for regulations and Memorandums of Understanding (MOUs) necessary to establish a "demonstration" commercial abalone fishery in the Southwest Zone of San Miguel Island

IV. EXECUTIVE SUMMARY

A. Red Abalone Demonstration Fishery at San Miguel Island (SMI)

The commercial sector, represented by the California Abalone Association (CAA), proposes a Restricted Access Fishery (RAF) for red abalone (Haliotis rufescens) at SMI. A community-based fishermen's harvesting cooperative will be developed in exchange for a harvest allocation to assist the California Department of Fish and Game (CDFG) with the management, enforcement, monitoring, and data collection of this fishery. This will be achieved by entering into a Memorandum of Understanding (MOU) and developing supporting regulations to ensure that the State retains oversight and that the abalone population continues to recover. The Alternative described here recognizes that responsible resource stewardship is inherently linked to the success of the cooperative which places the health and habitat of the abalone population above all other considerations.

San Miguel Island

B. Total Allowable Catch (TAC)

A TAC of 10,728 abalone over 8 inches (203mm) is recommended for the Southwest Zone of SMI. A bootstrap analysis (Appendix G) of the 2008 survey data was conducted to create a TAC Decision Table (Section VI) that illuminates the tradeoffs associated with different population probabilities and catch. Using this analysis, there is a 95% probability that 10% of abalone larger than 8 inches in the Southwest Zone is equal to or greater than 10,728.

The CAA proposes that 90% of the TAC be allocated to the commercial sector as the Total Allowable Market Catch (TAMC) and the remaining 10% allocated to the recreational sector as the Total Allowable Recreational Catch (TARC). A change in the TAC would not affect these allocation percentages. These percentages reflect historical allocations based on CDFG catch records. The commercial sector believes this is an equitable division because of the existing recreational-only fishery above San Francisco to the Oregon border. The commercial cooperative will divide its TAMC allocation among its members in an efficient, safe, and ecologically sustainable manner. The initial TAMC allocation will be divided equally among all participating cooperative members.

The TAC recommended in this alternative is based on a conservative estimate that preserves over 80% of the population's spawning potential, and is considered sustainable over both the short and long term. This alternative's recommended TAC represents 1% of the total abalone estimated at SMI. Populations in the Northwest, Northeast, and Southeast Zones, as well as in the Judith Rock Marine Reserve (in the Southwest) will remain untouched.

Precautions built into this alternative include:

1. An increased size limit
2. A conservative TAC
3. Eliminating incidental mortality of sub-legal abalone by only handling emergent abalone that can be easily measured
4. Harvesting 30% or less of abalone in a group to protect spawning aggregations and prevent potential "Allee effect"
5. Using a conservative population estimate based on data from non-invasive survey protocols that do not detect cryptic abalone.

Uncertainty is inherent in managing natural resources. This alternative reduces future uncertainty by collecting fishery independent data in both fished and unfished areas to closely monitor and adaptively manage abalone populations. These data will inform a "Decision Tree Process" which sets the annual TAC in order to maintain long term target abundance, and allows for a TAC of zero if certain triggers are met.

C. Information Used to Support the TAC

Three years of collaborative surveys were conducted to assess the population at SMI. Data from the 2006 and 2007 surveys, along with historical catch and fishery-independent data was used by the AAG Technical Panel (TP) to construct a suite of fishery models to assess the population at SMI.

In February 200, these modeling results and the associated TP reports along with data inputs were discussed and reviewed by an independent Review Committee (RC) composed of fishery scientists. The RC determined the modeling work and the related reports were incomplete and a second round of modeling work was recommended. This second round has not currently been commissioned due to a lack of funding. It is difficult to draw conclusions from the TP model and reports, especially since the model did not project forward more than one year in each fishing scenario or provide information on the long-term growth potential of the SMI population, as the RC recommends.

This commercial alternative focuses on the RC report "Evaluation of the Red Abalone Stock Assessment by the Review Committee In Support of Deliberations of the Abalone Advisory Group" (2009) which recommends "a program of experimental fishing should be considered for the Southwest Zone as an initial step in pursuing the option for removals." In pursuit of this experimental fishery, the RC also recommended that the size limit be raised to 8 inches, and that the initial TAC be set at 10% of the abalone over 8 inches in the Southwest Zone. The RC also stated, "given such a relatively high age at first capture, this 10% proportional take is well below standard fishing mortality reference points."

The CAA has developed this alternative pursuant to the recommendations of the RC, examples set by a number of foreign abalone fisheries, and the best available science. This alternative is further informed by the "A New Beginning for Abalone Management in California: Critique and Comment on the Abalone Advisory Group's Discussions" (2009) by Dr. Jeremy Prince and Bren School PhD candidate Sarah Valencia which describes how the SMI fishery can be opened and adaptively managed using a TAC "Decision Table" phased to a "Decision Tree Assessment Process".

D. Allocation Mechanisms

As described above, the initial TAC proposed in this alternative is based on the TAC "Decision Table". In the years to follow fishery dependent and independent data will continue to inform the "Decision Tree Assessment Process" (VI) to set the annual TAC. The "Decision Tree Assessment Process" will adjust the TAC up or down each year in response to Biological Reference Points (BRPs). These BRPs include ecological triggers such as; sea surface temperature, kelp availability, and long-term abundance targets.

The "Decision Tree" framework will:

1. Use harvest data collected by fishermen
2. Use unfished populations data as a reference
3. Detect and respond to changes in population levels and environmental conditions
4. Accommodate advances in knowledge regarding abalone management to maximize spawning biomass and recruitment

If certain triggers are detected, the "Decision Tree" recommends a zero TAC until data collected provides evidence of population sustaining ability. For example, if a disease outbreak occurs, fishing can be curtailed or terminated to ensure that all surviving spawning abalone are preserved to rebuild the stock following the outbreak.

Annual allocation of a TAMC to the cooperative will be based on the cooperative meeting stated obligations each year. The state will determine if fishing should continue based on the health of the population.

E. Management Approach

<u>Community-Based Harvest Cooperative</u>: Development of a community based cooperative management structure is currently underway by the CAA. This cooperative will meet all the guidelines and requirements set forth by the State of California and the Federal Fishermen's Collective Marketing Act (FCMA) of 1934. The cooperative's legal structure will be based on Articles of Incorporation, bylaws, membership applications, and marketing agreements provided by California attorney Kendall L. Manock of Baker Manock & Jensen in consultation with attorney Joseph M. Sullivan of Mundt MacGregor L.L.P. The cooperative will also take the necessary steps to qualify for the FCMA's limited antitrust exemption.

CDFG Code 5522 (e) states "If the Commission determines that commercial fishing is an appropriate management measure, priority for participation in the fishery shall be given to those persons who held a commercial abalone permit during the 1996/97 permit year." Therefore, all individuals who held an abalone diving permit in the 1996/97 fishing year will be invited to participate in this cooperative.

<u>Shared Management Framework</u>: A shared management framework will be developed with CDFG through a combination of regulation and MOUs. This approach uses the harvesting cooperative to fulfill the necessary shared management activities and makes it possible to achieve comprehensive sustainable fishery management at a lower cost to the state. The harvesting cooperative will:

1. Take responsibility for directing specific harvest and data collection activities
2. Ease the burden to the state associated with enforcement duties

3. Assist with data management
4. Educate the fishing community on responsible marine resource stewardship
5. Create a cohesive and motivated community of market abalone divers that will respond wisely to the challenges of sustainable fisheries management

Under this shared management framework the state will be responsible for:

1. Setting the TAC
2. Providing licenses and permits
3. Evaluating the fishery and cooperative performance through an annual review process

Restricted Access Fishery (RAF): In general, the goal of the Fish & Game Commission Policy on "Restricted Access Commercial Fisheries" (Appendix A) is to enhance the state's ability to manage its commercial fishery resources and contribute to sustainable fisheries management. The RAF proposed for red abalone at SMI meets this goal by:

1. Providing a means to match the level of effort in a fishery to the health of the fishery resources,
2. Promoting sustainable fisheries and giving fishery participants a greater stake in maintaining sustainability,
3. Providing a mechanism for funding fishery management, research, monitoring, and enforcement activities,
4. Maintaining long-term economic viability in a fishery
5. Providing long-term social and economic benefits to the state and fishery participants
6. Providing for an orderly fishery while expanding opportunities for the commercial fishing industry to share management responsibility with CDFG

Harvest: An annual "fine scale" harvest plan will be developed to effectively and accurately manage and assess the abalone resource. The cooperative will implement a regional management approach and direct specific harvest by assigning fishermen to individual micro blocks. This micro block system will foster "community stewardship" by instilling a sense of direct responsibility in fishermen for the blocks they harvest. This approach will link allocation to specific harvest blocks and each member will harvest their allocation according to this annual harvest plan developed by the cooperative in conjunction with CDFG. To achieve fine scale management that is information driven, harvest areas will be divided into 1/10th mile blocks. Harvest and population data collected at this scale will provide spatially explicit information for refining management approaches.

"Decision Tree Assessment Process": The "Decision Tree Assessment Process" will remove much of the annual burden of management from CDFG by providing a prescriptive approach to setting the TAC based on scientific data. The CAA will work with fishery scientists to finalize a Decision Tree specific to red abalone at SMI. The Decision Tree will be in a user-friendly format and will be provided to both the cooperative management and CDFG so that each party can independently verify the TAC recommended by the Decision Tree each year. A secure web-based data management system that can be accessed by the CAA, cooperative, and CDFG will be set up to inform the stock assessment process.

Annual Evaluation and Report: An annual evaluation process will be established to determine success of the cooperative in fulfilling management objectives. The cooperative will be required to complete an annual report documenting its compliance with the terms and conditions stated by the MOU(s) in place and under which its annual allocation was issued. Another purpose of the report will be to determine how well the cooperative met its goals for the year. Some evaluation and report areas include:

1. Population trends over time
2. Data collection and research
3. Fishery dependent data
4. Enhancement
5. Revenue generated from the fishery
6. Management costs

F. Enforcement Approach

This alternative recognizes two levels of enforcement: government law enforcement agencies and the fishing community. Government enforcement can be seen as a joint effort between CDFG, Channel Islands National Parks Service, Channel Islands National Marine Sanctuary, and the Coast Guard. By vertically integrating the harvest activity and wholesale marketing of abalone with a cooperative, many enforcement concerns can be addressed by the fishing community. A comprehensive state and community enforcement approach also includes:

1. Tag tracking system
2. Single port of landing
3. Season restrictions
4. Harsh penalties
5. Vessel identification/monitoring systems
6. Trace Register (www.traceregister.com) as the independent/third party "registry"

The cooperative will enforce its community bylaws on its members and also aide and assist in enforcement of state regulations. The cooperative will implement an "Island Watch Program" within the existing commercial fisheries to look for suspicious behavior by commercial and recreational vessels. A cooperative funded reward program for information on poaching could also be considered.

Tags and Tracking System: Tags (ARMP Section 7.1.3.) are the cornerstone in connecting biological monitoring, management and enforcement. A system will be developed using a database supported by the tag and logbook system which will identify individual abalone and connect them to a specific diver and area. The cooperative will set up a digital chain-of-custody system to help prevent illegal abalone from entering the marketplace and identifying them if they do. A simple web-based, automated database will be used to track abalone through the entire supply chain (fishery to consumer). It is proposed that the cooperative and all abalone handlers use Trace Register (Section IX) as the independent/third party "registry" into which product, source, and tracking information are entered, secured, and shared throughout the supply chain.

G. Monitoring Approach

Fishery Dependent Data: Each fisherman in the cooperative will be required to complete a "Red Abalone Harvest Log" page for every harvest dive. Each Harvest Log will have sequentially numbered two-part carbon sheets. The "Log" format will provide fishery dependent data that will be used to track the TAMC, determine catch-per-unit-of-effort (CPUE), and enhance understanding of spatial distribution to assist in managing the resource.

Fishery Independent Data: The CAA and the cooperative will work with CDFG to collaboratively train fishermen and design surveys to monitor:

1. Biological Reference Points
2. Spatial distribution
3. Size frequency
4. Densities in both fished and unfished areas

These data will provide detailed information on the fisheries impact on population growth and inform the yearly "Decision Tree Assessment Process" to set the TAC. The 2009 survey protocols will use a Before-After-Control-Impact (BACI) design to monitor population trends at specified areas of SMI. This design will reduce costs. The resulting density information can be used for setting future fishery parameters.

H. Funding Mechanisms

The cooperative will enter into an MOU with the state which describes the economic responsibilities and obligations of the cooperative. One goal of the cooperative will be to reduce CDFG costs and create its own revenue stream to pay for education and fishery related monitoring and enforcement.

I. Key Regulations Needed

Specific regulations needed to manage the TAMC are described in Appendix E of the "Red Abalone Market Fishery Operating Guidelines". These regulations include:

1. Season
2. Eight inch minimum size limit
3. Harvest zones
4. Restricted access
5. Gear
6. Landing receipts
7. Taxes and licensing
8. Tamper proof tags

Additional regulations regarding the cooperative's ability to receive an allocation and the content of the necessary MOU(s) that outline the cooperative's responsibilities will also need to be developed.

V. REGULATIONS AND MOU'S

A shared management framework will be developed with CDFG through a combination of regulations and MOUs. This framework will use the cooperative to fulfill a portion of the shared management activities and make it possible to achieve comprehensive sustainable fishery management at a lower cost to the state. The cooperative will:

1. Take responsibility for directing specific harvest and data collection activities
2. Reduce the need for state associated enforcement duties
3. Assist with data management
4. Educate the fishing community on responsible marine resource stewardship
5. Create a cohesive and motivated community of market abalone divers that will respond wisely to the challenges of sustainable fisheries management

Under this shared management framework, the state will be responsible for:

1. Setting the TAC
2. Providing licenses and permits
3. Evaluating the fishery and cooperative performance through an annual review process

It is anticipated that CDFG will develop regulations when the fishery is reopened. The cooperative would like to work jointly with CDFG to develop those regulations. Appendix E contains suggested regulations based on:

1. Commercial Fishing Provisions 95-01 for Abalone Diving (as of January 1, 1995)
2. Excerpts from the Fish and Game Code
3. Excerpts from the California Code of Regulations (Title 14)
4. Fishermen proposed regulatory modifications regarding the cooperative

VI: TOTAL ALLOWABLE CATCH (TAC)

An initial Total Allowable Catch (TAC) of 10,728 abalone 8 inches (203mm) or over is currently recommended for the Southwest Zone of SMI. This initial TAC based on the TAC Decision Table (Table 1), is conservative and includes the following precautions:

1. TAC represents 1% of the total abalone estimated to be at SMI
2. Populations in the Northwest and Southeast Zones, as well as in the Judith Rock and Harris Point Marine Reserves will remain unharvested (Map A)
3. TAC is based on a conservative population estimate based on data from non-invasive survey protocols that do not detect up to 30% of the abalone over 150 mm which remain cryptic
4. Increased size limit (from 7 ¾ to 8 inches)
5. Eliminate incidental mortality of sub-legal individuals by only handling emergent abalone that can be easily measured and clearly meet the 8 inch size limit
6. Harvest no more than 30% of legal-sized abalone in a given aggregation to protect spawning potential and preserve nearest-neighbor distances
7. TAC preserves over 80% of the Spawning Potential Ratio (SPR) in the area to be fished. A common target SP of 50 - 60% is considered precautionary.

A. TAC Development

Three years of collaborative surveys were conducted to assess the population at SMI. Data from the 2006 and 2007 surveys, along with historical catch and other fishery-independent data were used by the AAG Technical Panel (TP) to construct a suite of fishery models to assess the population at SMI.

These modeling results and the associated TP reports along with data inputs were discussed and reviewed by an independent Review Committee (RC) composed of fishery scientists in February 2009. The RC determined that the TP modeling work and the related reports were incomplete and a second round of modeling work was recommended but not commissioned to date due to a lack of funding. Therefore, it is difficult to draw conclusions from the TP model and reports, especially since the model did not project forward more than one year in each fishing scenario or provide information on the long-term growth potential of the SMI population, as the RC recommended.

This initial TAC for the Southwest Zone was determined based on the RC recommendations, examples set by a number of foreign abalone fisheries, and the best available science. In particular the RC indicated that “a program of experimental fishing should be considered for the Southwest Zone as an initial step in pursuing the option for removals.” The complete RC Report “Evaluation of the

Red Abalone Stock Assessment by the Review Committee in Support of Deliberations of the Abalone Advisory Group" can be referenced in Appendix F.

In pursuit of this experimental fishery, the RC also recommended that the size limit be raised to 8 inches, and that the initial TAC be set at 10% of the abalone over 8 inches in the Southwest Zone. The RC also stated, "given such a relatively high age at first capture, this 10% proportional take is well below standard fishing mortality reference points." This TAC is further justified and informed by the "A New Beginning for Abalone Management in California" (Appendix G) by Dr. Jeremy Prince and Bren School PhD candidate Sarah Valencia, which describes how the SMI fishery can be opened and adaptively managed using a TAC Decision Table phased to a Decision Tree.

B. Decision Table Designed to Develop Initial TAC

A bootstrap analysis of the 2008 survey data was conducted to create the initial TAC Decision Table (Table 1) that illuminates the tradeoffs associated with different population probabilities and catch. Using this analysis, there is a 95% probability that 10% of abalone larger than 8 inches in the SW zone is equal to or greater than 10,728. This analysis is described in detail in "A New Beginning for Abalone Management in California".

Table 1: Harvest Decision Table using 2008 San Miguel Survey Data

Total Population In SW Zone	320,220	335,562	345,560	353,252	359,640	365,186
Population> 203mm	107,278	112,418	115,767	118,344	120,484	122,342
Harvest Fraction	**95%**	**90%**	**85%**	**80%**	**75%**	**70%**
0.05	5,364	5,621	5,788	5,917	6,024	6,117
0.1	**10,728**	11,242	11,577	11,834	12,048	12,234
0.15	16,092	16,863	17,365	17,752	18,073	18,351
0.2	21,456	22,484	23,153	23,669	24,097	24,468
0.25	26,819	28,104	28,942	29,586	30,121	30,586
0.3	32,183	33,725	34,730	35,503	36,145	36,703
0.35	37,547	39,346	40,518	41,420	42,169	42,820
0.4	42,911	44,967	46,307	47,338	48,194	48,937

C. Decision Tree Assessment Process

The strength of the Decision Tree process lies in its simplicity. It makes few assumptions and requires minimal inputs, but prescribes catch levels based on continuous monitoring to achieve long range target stock levels. By incorporating MPAs as a reference stock, it integrates an ecosystem based approach into fisheries management, and facilitates monitoring of California's MPAs. In addition, involving fishermen in the stock assessment process, promotes greater industry involvement and accountability in management. This will support the implementation of various harvest strategies.

Uncertainty is inherent in managing natural resources. Future uncertainty can be reduced by collecting fishery independent data in both fished and unfished areas (Figure 1) to closely monitor and adaptively manage abalone populations. These data will inform a Decision Tree Assessment Process which:

1. Sets the annual TAC to achieve long term target abundances
2. Allows for a TAC of zero if certain triggers are met

The Decision Tree Process will adjust the TAC up or down each year in response to Biological Reference Points (BRPs). These BRPs include ecological triggers such as sea surface temperature, kelp cover, kelp abundance, long term abundance targets, population size structure and spawning potential.

The SMI Decision Tree Assessment Process (Figure 2) will embrace a conservative management approach for protecting more than 80% of Spawning Potential Ratio (SPR). This SPR is the proportion of spawning conserved in the fished population relative to the level of spawning expected if the population was left unfished. Since fisheries biologists and managers worldwide recommend SPR targets of 50% to 60% to conserve fish stocks, a target of over 80% provides a precautionary margin for environmental variability, poaching, and other events that might increase rates of mortality. Using this target the SMI abalone population is expected to continue re-building during the projected harvest. The Decision Tree will be used to assess stock relative to the target level of SPR and revise the annual TAC according to relative trends.

The Decision Tree framework will:

1. Use harvest data collected by fishermen
2. Use unfished (MPAs) populations as a reference
3. Detect and respond to changes in population levels and environmental conditions
4. Accommodate advances in knowledge regarding abalone management to maximize spawning biomass and recruitment

If certain triggers are met, the Decision Tree can recommend a zero TAC until data provides evidence the population is capable of sustaining itself again. For example, if a disease outbreak occurs, fishing can be curtailed or terminated to ensure all surviving spawning abalone are preserved to rebuild the stock following the outbreak.

Figure 1: San Miguel Island with Kelp Coverage and Marine Protected Areas

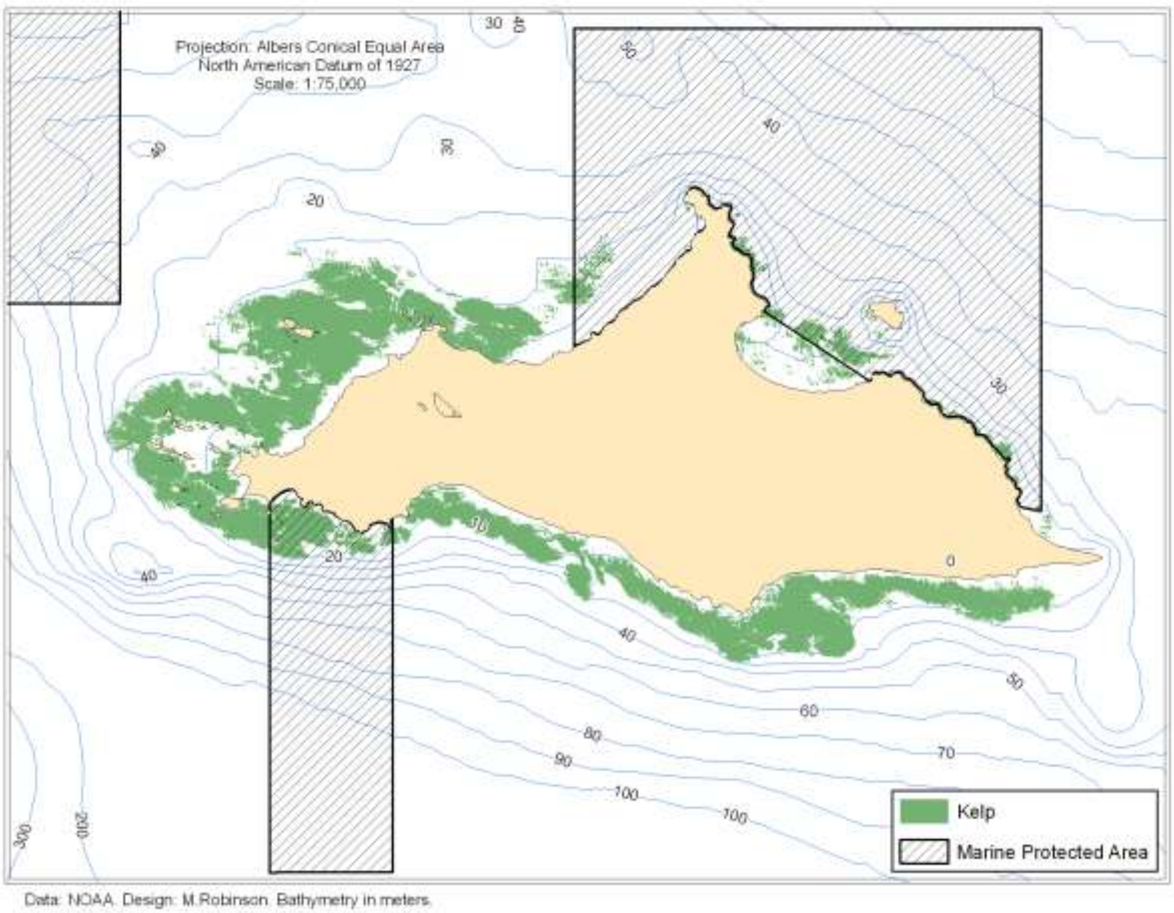
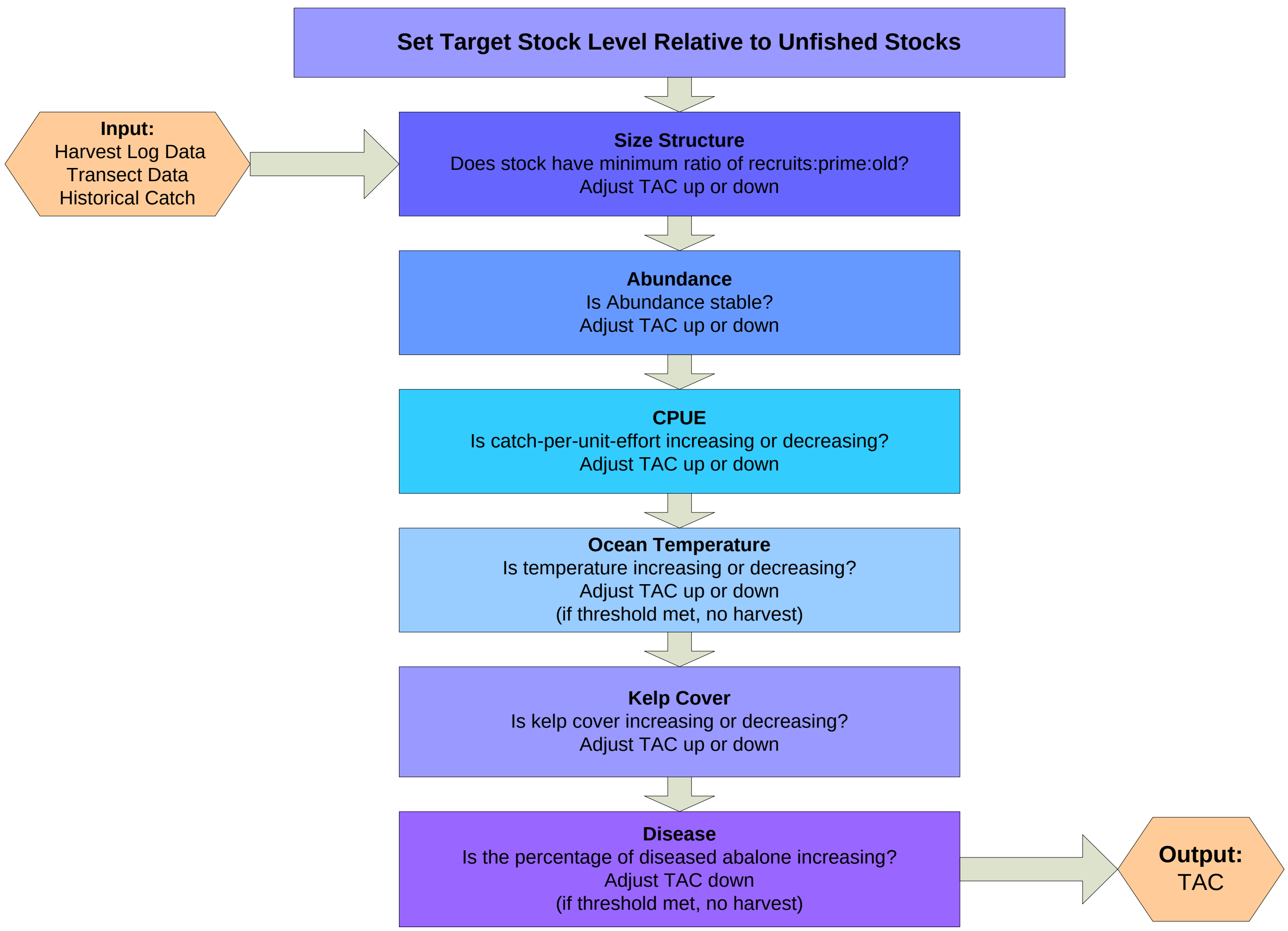


Figure 2: Conceptual representation of a Decision Tree Assessment Process for Red Abalone



VII: Resource Assessment and Data Collection

"The core of the MLMA is the principle of basing decisions on sound science and other useful information. With this in mind, the MLMA includes, as a general objective, promotion of research on marine ecosystems that will enable better management decisions." The MLMA also calls for basing decisions on the best available scientific information along with other information that CDFG and Commission possess.

While the MLMA emphasizes scientific information, it also recognizes the value and importance of other sources of information, such as local knowledge, in making decisions regarding the conservation and sustainable use of California's marine life resources.

The SMI data collection program should be thought of as an evolving process. A large set of abalone population density and size frequency data has been collected through collaborative surveys conducted in 2006, 2007, and 2008. Those surveys termed "Snapshots", gave a good impression of the overall population status at SMI. In 2009, the purpose will be to execute a BACI designed survey to more closely monitor population trends within specified areas at SMI. The survey data will be used to inform analysis of the population status at the island and provide data for the Decision Tree.

When fishing begins, Harvest Logs will be used to gather fishery dependant data. These data will be reviewed annually in conjunction with ongoing fishery independent data to identify population changes. Data gap analysis will be also conducted annually for both fishery dependent and independent data. Improving data collection methods and techniques, identifying data gaps, and informing changes in management will all be components of the data collection and analysis process.

Fishery Dependent Data: Fisherman in the cooperative will be required to complete the "Red Abalone Harvest Log" for every dive during harvest. Each Harvest Log will have sequentially numbered two-part carbon sheets and the format will provide fishery dependent data that will be used to track the TAMC, determine catch-per-unit-of-effort (CPUE) at a fine scale to enhance understanding of spatial distribution and assist in managing the resource.

Fishery Independent Data: The CAA and/or the cooperative will work with CDFG to collaboratively design and conduct surveys to monitor:

1. BRPs
2. Spatial distribution
3. Size frequency
4. Densities in both fished and unfished areas

These data will provide information on the impacts of the fishery on population growth, and feed the yearly Decision Tree Assessment Process to set the TAC.

A. Data Coordinator

In the short term the CAA and/or cooperative will take the lead role in developing data systems, survey designs, and stock assessments.

In the long term a Data Coordinator will be recruited to work with the cooperative and CDFG managers. This important role is expected to evolve and expand over time. The recruit will also be someone who can work closely with the industry, its associated researchers, experts and agencies. The person should have training in fisheries ecology and quantitative stock assessment, but might not need to have a great body of work experience in the early stages. Most importantly he/she should have a personality that will relate well to industry members, as this will be absolutely essential if his/her role is to succeed.

Broadly speaking the Coordinator's role will include, but not be limited to:

1. Become familiar with the industry including, core CAA and/or cooperative members and key agency staff, the port, and the fishing techniques being used
2. Participate in the design and implementation of the survey system
3. Participate in the development of stock assessment
4. Work with the relevant agencies and scientists to collate and organize the data required to formalize a stock assessment for the resource
5. Act as the interface between industry and CDFG in formal stock assessment, research and management process
6. Document formalized stock assessment
7. Update the stock assessment as new data becomes available
8. Participate in the design of the Harvest Log and other required electronic log books
9. Collect, error check, organize, and archive survey data being entered onto the Harvest Log (with assistance from the divers)
10. Take responsibility for ensuring that any additional electronically collected data are error checked and transferred into the central database

11. Maintain the central database and any associated web sites
12. Coordinate harvest activities and work closely with CDFG enforcement in those activities
13. Act as liaison with Trace Register
14. Work with the divers to ensure that they and other volunteer surveyors have the required training and equipment to conduct surveys and work as an effective data collection team
15. Act as liaison to divers and volunteer surveyors to keep them informed about their research role
16. Report activities to the CAA and/or cooperative Board of Directors
17. Prepare required annual reports
18. Attend CAA, cooperative, CDFG, Commission, and other related meetings

B. Survey Training

All data collectors will be trained by the cooperative and/or CDFG in the current survey protocol. The cooperative will continue to work closely with CDFG in data collection training.

C. Annual Surveys

The long term plan is to move towards greater reliance on fishery dependent data, which is more cost effective to collect than fishery independent data. Initially fishery dependent data will continue to be collected and calibrated to fishery independent data. In time, more extensive fishery independent data collections will be triggered by harvest data. If, for instance, the size frequency of harvested abalone were to drop, this might indicate the need for increased fishery independent sampling to help determine possible causes.

1. Fishery Dependent Monitoring

    a. Harvest log
        i. Spatially explicit
        ii. Size/weight catch
        iii. Estimate of remaining
        iv. Area searched/time CPUE
        v. Habitat information
        vi. Ability to map all data 10x10 meter

2. Fishery Independent Monitoring (in and out of reserves)

    a. Band transects
        i. Spatially explicit
        ii. Size frequency
        iii. Density

Tagged Abalone at Miracle Mile

b. Timed swim
    i. Spatially explicit
    ii. Size frequency
    iii. Rough density estimate

3. Research

    a. Movement and growth studies are ongoing at Miracle Mile and Crook Point at SMI
    b. Artificial Recruitment Modules (ARMs) have been placed at the "Miracle Mile"
    c. Permanent transect/reference sites at Castle Rock, Judith Rock Reserve, Tyler Bight, Miracle Mile, Wycoff Ledge, Crook Point and Harris Point

D. SMI Red Abalone Survey Protocols

The 2009 survey protocols were designed to standardize observations, increase statistical power, and reduce costs (see Appendix H). The 2006, 2007, and 2008 protocols are available at http://ftp.dfg.ca.gov/Public/R7_MR/AAG/.

E. Annual Stock Assessment To Set TAC or Other Fishery Parameters

1. Data Used to Inform Decision Tree Assessment Process

    a. Fishery dependent data
        i. Size structure of catch
        ii. Catch effort trends
    b. Fishery independent data
        i. Size structure of population in/out of reserves
    c. Biological Reference Points
        i. Size structure
        ii. Abundance
        iii. CPUE
        iv. Ocean temperature
        v. Kelp cover
        vi. Disease

VIII: ECONOMIC VIABILITY

California Fish and Game Code, Section 711(2) states that "the costs of commercial fishing programs shall be provided out of revenues from commercial fishing taxes, license fees, and other revenues, from reimbursements and federal funds received for commercial fishing programs, and other funds appropriated by the Legislature for this purpose".

The cooperative will enter into an MOU with the state that describes its required economic responsibilities and obligations. One goal of the cooperative will be to reduce CDFG costs and create its own revenue stream to pay for education and fishery related monitoring and enforcement obligations. It is anticipated that the State's revenue will be generated through the collection of permit and permit transfer fees.

A. Bren School Group Project

This section will also be further developed by completion of the Bren School Group Project entitled "Optimal Design and Management of Commercial Fishing Cooperative for the San Miguel Red Abalone Fishery" (Appendix D). This study will assess the economic and environmental viability of the proposed cooperative. It will also make recommendations for revising and enhancing the cooperative design in order to maximize profits, while ensuring the long term sustainability of the fished abalone population at SMI.

To accomplish these goals, objectives of the Bren study are to:

1. Utilize environmental and economic data to perform a cost-benefit analysis of a cooperative management structure provided by the CAA, in order to evaluate the long-term financial viability of the proposed fishery
2. Determine alternative management structures for the cooperative, developed from discussions with the CAA and recommendations drawn from collected case studies of similar fishing cooperatives across the globe
3. Conduct cost-benefit analyses of these alternative plans, and synthesize economic viability reports in order to provide the CAA with concrete data on the financial impacts of potential management scenarios and ecological states
4. Develop a comprehensive report assessing the economic viability of a self-funded SMI commercial abalone fishing cooperative along with providing recommendations for optimizing profits while ensuring the sustainability of the resource

This project is significant because abalone is a valuable resource to the State and people of California. As such, if the fishery is to be opened, it must be managed and cared for so as to ensure its economic and ecological sustainability.

The Bren study will help properly design and implement a commercial harvesting cooperative that will:

1. Present a state-of -the-art example of fine scale fishery management with catch shares, a harvest cooperative, and shared management
2. Help shape future policies on the implementation of catch shares and/or fishing cooperatives and/or shared management
3. Demonstrate the viability of fisheries management strategies designed to function in a environmentally sustainable fashion
4. Support local fishermen, restaurant owners, and the local food movement

IX: COOPERATIVE OPERATING STRUCTURE

The California Abalone Cooperative (CALAB) is a member owned community-based fishermen's cooperative. This monitoring, harvesting, and marketing association will return profit earned to its members. This cooperative will be organized under the guidelines set forth by the Fishermen's Collective Marketing Act (FCMA). It will meet all the guidelines and requirements set forth by the State of California.

The economy of scale for this small fishery strengthens the need to develop a cooperative structure that will include those who held abalone diving permits in the 1996/97 fishing year. A single cooperative will efficiently facilitate, maintain, and fund internal management controls as well as provide consistent shared-management with the state.

This small fishery will be best served with a small cooperative membership, as it will be difficult to manage a large number of members. Therefore, it will be necessary to have a plan to reduce the number of participants over time, and to maintain the cooperative's efficiency and ability to function responsibly. Divers that are considering membership in this cooperative will be expected to accept all the explicit responsibilities for the shared management of this fishery.

A. Mission Statement

The California Abalone Cooperative places the health and habitat of the abalone resource above all other considerations and will co-manage an abalone fishery while recognizing the link between stewardship of the resource and a successful cooperative.

B. CALAB Goals

1. Meet the members' needs for affordable and high-quality marketing and management services
2. Invite all individuals who held an abalone diving permit in the 1996/97 fishing year to participate in this cooperative
3. Ease enforcement duties for the State
4. Co-direct monitoring and assist the State in data management
5. Educate fishing and public communities
6. Enhance the abalone resource
7. Develop constructive community relationships

C. Allocation to Harvesting Associations

Total Annual Market Catch (TAMC) will be allocated annually to the abalone harvesting association(s) that files an application which satisfies regulatory criteria. Such criteria will include:

1. All members hold a current restricted access permit
2. An abalone harvesting plan that conforms to the fishery management measures in effect (such as minimum size requirements, harvest location documentation, prohibitions on high-grading, tagging requirements, etc.)
3. A monitoring and enforcement system sufficient to enforce harvesting plan requirements and prevent over-harvest of the association's allocation
4. Data gathering and reporting practices that satisfy stock assessment requirements
5. An annual report and compliance audit that demonstrates the association has complied with the terms and condition of its prior allocation

Allocation criteria will be reviewed and modified on a periodic basis to insure such criteria are aligned with abalone stock management goals.

1. Allocation to CALAB

   CALAB will receive its share of the Total Allowable Market Catch (TAMC), provide access to that allocation for its members, and determine how that allocation is divided among its members. The cooperative will divide its allocation of TAMC among its members in the most efficient, safe, and ecologically sustainable manner. The initial TAMC allocation will be divided equally among all the participating cooperative members.

   Annual allocation of the TAMC to the cooperative will also be reviewed based on the cooperative's ability to meet stated obligations each year, and the State will determine if fishing should continue based on the health of the population.

D. Member Participation

In order to provide the framework for its members to share in the management of the resource with the State, members participating in this cooperative will be required to:

1. Possess a commercial abalone diving permit issued by CDFG
2. Sign this cooperative's "Marketing Agreement "
3. Sign and agree to act under this cooperative's "Code of Conduct"
4. Agree and abide to cooperative bylaws
5. Be fully trained in data collection protocols

6. Collect data as required (Section IX)
7. Dive only their share of the total allocation
8. Pay initial membership assessment to the cooperative
9. Participate in capitalizing the cooperative

"Moe: A Hypothetical Day in the Life of a Cooperative Abalone Diver" can be found in Appendix J.

E. Shared Management Framework

During each season the cooperative will assume primary responsibility for ensuring the market catch fishery is conducted in a manner consistent with CDFG's management plan, as reflected in harvest allocation application criteria. By using fishery participants within this cooperative's framework to complete the shared management activities (listed below) it will be possible to achieve comprehensive sustainable fishery management at a lower cost. This harvesting cooperative will:

1. Supply the formal and legal structure to guide harvest activity in a way that least impacts the resource and most informs the stock assessment model
2. Provide the fishermen who will work as co-managers with State managers
3. Create a cohesive and motivated community of market abalone divers that will respond wisely to the challenges of sustainable fisheries management
4. Supply harvest data in addition to fishery independent data
5. Maintain a data management system, provide data to CDFG, and assist in analyzing the data
6. Provide diving schedules and harvesting plans to CDFG mangers and enforcement personnel

Some of the state's responsibilities in this shared management framework will be to:

1. Set the TAMC
2. Provide licenses and permits
3. Evaluate this cooperative's performance through an annual review process

F. Information to Support Resource Assessment

The cooperative in coordination with CDFG will provide fishery independent data that will inform design making process described in an approved Decision Tree. Specific descriptions of fishery monitoring and resource assessment research can be found in Section VII.

G. Micro Block Harvest

An annual fine scale harvest plan will be developed to effectively and accurately manage and assess the abalone resource. This cooperative will implement a regional management approach and direct specific harvest by assigning fisherman to individual micro blocks. This micro block system will foster "community stewardship" by instilling in fishermen a sense of direct responsibility for the blocks they harvest. This approach will link allocation to specific harvest blocks and each member will harvest their allocation according to this annual harvest plan developed by the membership in conjunction with CDFG.

In order to achieve fine scale management that is information driven, harvest areas will be divided into $1/10^{th}$ mile blocks. The $1/10^{th}$ mile block approximates the scale on which harvest occurs, which is typically a dive hose length. Data collected at this scale will provide spatially explicit information for refining management approaches.

Cooperative members will pool catches and profits, and use a directed micro block harvest that will eliminate the "race to fish" and conserve the resource by:

1. Allocating a percentage of the overall TAMC to each member
2. Developing evolving catches for each micro block
3. Assigning each member to several micro blocks for harvesting and data collection
4. Adopting a strategy that conserves aggregations
5. Providing information to adjust the TAMC

H. Harvest Log

Each fisherman will be required to complete the "Red Abalone Harvest Log" (Figure 3) for every micro block in which they harvest. Each Harvest Log will have sequentially numbered two-part carbon sheets and the format will provide fishery dependent data that will be used to:

1. Track the TAMC
2. Determine catch-per-unit-of-effort (CPUE)
3. Track stock structure
4. Enhance the understanding of spatial distribution to assist in managing the resource

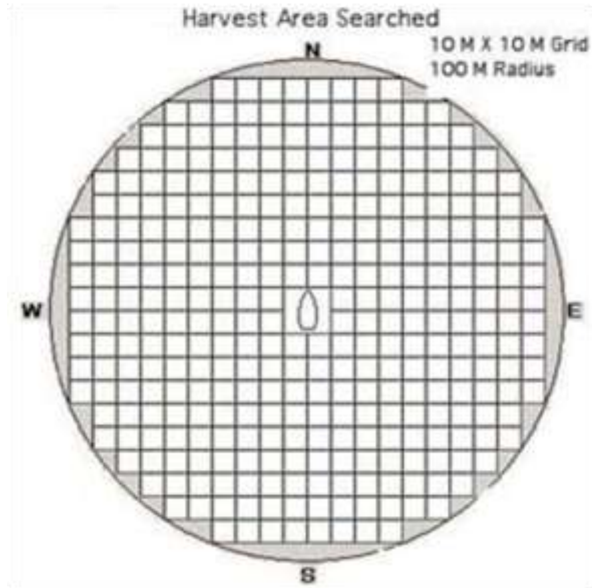
The Harvest Log will supply the following information:

1. Diver and boat information
2. Micro block fished
3. Latitude and longitude
4. Time spent harvesting
5. Estimate of area searched during harvest
6. Size and weight of all harvested abalone
7. Estimate of unharvested abalone, both solitary individuals and the number and size of aggregations
8. Observations of bottom type and relief

Figure 3: Red Abalone Harvest Log (completed)

Log #	**001**
Date	**02/15/09**
Diver	**M. Harrington**
L #	**02910**
Vessel	**Uno Mas**
F&G Boat #	**41291**

Signature			
Latitude	**34 01.416**	F&G Block	**690**
Longitude	**120 23.693**	Micro Block	**86-53**



Depth Range	**15-25**	1
Harvest Time	**1:05**	2
Abalone Harvested	**15**	3

Substrate Relief Harvest Area			4
<1M	1-3	>3	
80%	**20%**	**0%**	

Substrate Type in Harvest Area				5
Reef	Boulder	Cobble	Sand	
75%	**20%**	**0%**	**5%**	

Solitary Abalone	**18**	6
Number of Aggregations	**5**	7
Size of Aggregations	**10/20/8/3/9/3/2**	8
Tag Numbers	**00001-00015**	9

Tag #/Size/Weight of Each Abalone 10		
1/212/1850	**2/209/1357**	**3/210/1290**
4/222/1780	**5/208/1230**	**6/250/2400**
7/225/1900	**8/231/1925**	**9/208/1300**
10/254/3510	**11/240/2150**	**12/204/1100**
13/206/1200	**14/218/1440**	**15/205/1260**

Comments	11

I. Harvest Log Instructions

Divers harvesting red abalone are required to complete the Harvest Log. A separate page must be used for each location. If the boat is moved and another dive made at a different location, another page must be used to record data for the new location.

A small writing slate will be carried by the diver while harvesting to record; substrate relief, substrate type, and a count of abalone and aggregations remaining in harvest area. Information from this slate will be entered on the harvest log page.

Divers must record data in every field of the log and sign each page. Upon landing, log page numbers and tag numbers of harvested abalone must be entered on a CDFG Fish Landing Receipt.

The data from this log will be used to inform the understanding of catch size structure and population structure for the abalone remaining and relate that information to specific locations. It will also be used to help create fine scale charts of the reefs in harvest areas. The data will be managed on the cooperative's data management system (currently under development) and data will be available to CDFG biologists.

Original pages containing completed harvest data must be returned to cooperative Data Coordinator upon landing.

Instructions for Completing the Harvest Log

The top of the form contains:

1. Latitude and longitude entered to the 1,000th of a minute
2. CDFG block number
3. 1/10th mile micro block

The harvest area searched diagram will have a mark in every 10 x 10 meter grid square where a diver searched for and/or harvested abalone. These marks are oriented to compass heading and not boat heading.

Additional information on the form includes:

1. Depth Range: Enter range of depth during search and/or harvest, in feet. **15-25**

2. Harvest Time: Enter time spent underwater searching for and/or harvesting abalone, in hours and minutes. **1:05**

3. Abalone Harvested: Enter number of harvested abalone at this location. **15**

4. Substrate Relief Harvest Area: Enter estimated percentages of the substrate relief in the harvested area. Percentages in three categories; relief < 1 meter (less than one meter), relief 1-3 meters, and relief > 3 meters (greater than three meters), Entries must total 100%. **80% 20% 0%**

5. Substrate Type in Harvest Area: Enter estimated percentages of four categories of substrate type in the harvested area. Reef any rock substrate that can't be moved, Boulder – rock > 0.5 m that can be moved, Cobble - all rock < 0.5 m, Sand (substrate fine enough to be able to insert your finger). Entries must total 100%. **75% 20% 0% 5%**

6. Solitary Abalone: Enter number of visible abalone not occurring within 1 meter of nearest neighbor remaining in harvested area. **18**

7. Number of Aggregations: An abalone within 1 meter of its nearest neighbor is considered an aggregation. If another abalone is less than a meter away from either it is also in that aggregation. Enter the total number of aggregations remaining in harvested area. **5**

8. Size of Aggregations: Enter number of abalone found in each aggregation remaining in harvested area. **10/20/8/3/9/3/2**

9. Tag Numbers: Enter tag number series used to mark harvested abalone. **00001-00015**

10. Tag#/Size/Weight of Each Abalone: Enter tag number followed by size in millimeters and weight in grams. **12/212/1850**

11. Comments: Enter information on swell, visibility, kelp canopy, red algae cover, water temperature at 20 feet, etc.

J. Decision Tree Assessment Process

The cooperative will provide a self-funded mechanism for collecting fishery independent data in both fished and unfished areas to closely monitor abalone populations. A SMI specific Decision Table, as described in Section VI, similar to that currently being used in South Australian abalone fisheries will be used to set the initial TAC.

Then a transparent prescribed decision making procedure, referred to as the Decision Tree Assessment Process, will be used to assess future management performance. It will also guide management changes in the harvest area. The Decision Tree compares stock structures in "no-take" areas with those in the fished areas, and size structure of the catch. These comparisons trigger simple robust management changes that will maintain desired abalone stock structure and spawning biomass levels in the fished areas. The abalone specific Decision Tree will also be used to adjust the TAC up or down each year in response to Biological Reference Points (BRP) such as:

1. Size structure
2. Long term abundance,
3. CPUE
4. Ocean temperature
5. Kelp cover
6. Disease

Additional ecological triggers include:

1. Sea surface temperature
2. Kelp availability
3. Oceanic conditions
4. Spawning potential

The cooperative will be responsible for assisting the state in monitoring stocks that help determine the annual TAC for this fishery. The Decision Tree will remove much of the annual burden of management from CDFG by providing a prescriptive approach to set the TAC and make other management changes.

Cooperative members will collect fishery independent data for use in the decision making process in an efficient, scientifically rigorous, and cost-effective manner. The cooperative will:

1. Work with scientists to track population fluctuations in response to fishing
2. Examine the effect of various harvest strategies in a spatial context on spawning biomass
3. Project recruitment and yield
4. Use the results to determine the optimal harvest strategy for the cooperative

Transparency is of paramount importance, so all fishery-independent collection methods and analyses will be independently vetted to ensure objectivity. The cooperative will work with CDFG to design and build a password-protected web-based data storage system to facilitate communication and data sharing between the two agencies.

K. Market Catch Tags

Tags (ARMP Section 7.1.3.) are the cornerstone in connecting biological monitoring, management and enforcement. A system will be developed using a database supported by the tag and logbook system which will identify individual abalone and connect them to a specific diver and area.

Each cooperative member will be issued Market Catch Tags, one per abalone, equal to their individual allocation. The cooperative will coordinate with CDFG regarding certification and distribution of the tags. These tags will be fixed to each abalone upon harvest. Each tag will identify the permit holder, be sequentially numbered, tamper proof, and use a bar code system. The tag will remain on the abalone all the way to its final destination (i.e., restaurant, etc.) to identify legally harvested abalone in the marketplace. Tags are only valid in the season which they are issued.

L. Market Catch Tag Tracking System and Security Procedures

Illegal, unreported, and unregulated (IUU) fishing is a serious problem that will not be tolerated by the cooperative. This practice not only devastates fisheries and marine ecosystems, but it also deprives honest fishermen of an opportunity to harvest valuable resources. The cooperative will use new technology and set up a digital chain-of-custody system to help prevent IUU abalone.

The cooperative will set up a digital chain-of-custody system to help prevent illegal abalone from being obtained. A simple web-based, automated database will be used to track abalone through the entire supply chain (fishery to consumer). At this time it is proposed that the cooperative and all handlers use Trace Register (www.traceregister.com) as the independent/third party "registry" into which product, source, and tracking information are entered, secured, and shared throughout the supply chain.

This digital chain traceability provides powerful tools for government regulators and for the industry because it delivers the facts necessary to identify and prevent illegal products from entering the supply chain. It also provides an important common platform on which government and market forces can work together to initiate and drive the coordinated and consistent actions necessary to eliminate illegal harvest. This system will not only help the cooperative meet its legal requirements but also protect their brand integrity and the abalone population from damage that is associated with illegal, unreported and unregulated harvest.

Sharing of information is vital to the shared management of this resource. Entering data into a central secure repository allows all parties to share the same up-to-date and accurate information. This dramatically reducing ambiguity and misunderstanding while increasing cooperation and coordinated action, even when working across many roles, and responsibilities. Having a central database holding key fishery related data, which builds over time, offers information that can be analyzed and reported on to drive decision making, risk management, and planning.

The current vision is for the tracking to begin with the cooperative when divers are assigned to specific harvest blocks. Harvest will take place and abalone will be immediately tagged as they are brought on board. The required “Harvest Log Book” information will be recorded at each harvest site and when divers arrive at the landing port, pertinent data will be entered into the web site’s database. CDFG personnel could easily access this password protected information via the internet, at any time. CDFG enforcement wardens could also use the site to identify who, where, and when abalone were harvested as well as where abalone were landed and where each abalone is.

At the cooperative handling facility, all abalone will be referenced in the database by their tag number. As abalone handling is completed, tag numbers will be recorded on the packing box and this information will also be entered into the database. As abalone is sold, all shipping information will be entered into the database. Whole abalone and shells will always retain tags and, as they are sold, all shipping information will be entered. In the case of processed abalone, a secondary numbered tag will be inserted through the meat. The movement of abalone from the processing facility to the end users will also be recorded into the database and be available for audit by those with the appropriate password.

California Fish and Game Codes 8043 (1.12.1) and 8050 (1.12.2) mandate that written records of landings and sales after landing are available for audit by enforcement wardens. Additionally, Fish and Game Code 8050 addresses end user accounting records requirements.

1. *Fish and Game Code 8043*

(a) Every commercial fisherman who sells or delivers fish that he or she has taken to any person who is not licensed under Article 7 (commencing with Section 8030), and every person who is required to be licensed under Article 7 (commencing with Section 8030) to conduct the activities of a fish receiver, as described in Section 8033, shall make a legible landing receipt record on a form to be furnished by the department. The landing receipt shall be completed at the time of the receipt, purchase, or transfer of fish, whichever occurs first.
(b) The landing receipt shall show all of the following:
(1) The accurate weight of the species of fish received, as designated pursuant to Section 8045. Sablefish may be reported in dressed weight, and if so reported, shall have the round weights computed, for purposes of management quotas, by multiplying 1.6 times the reported dressed weight.
(2) The name of the fisherman and the fisherman's identification number.
(3) The department registration number of the boat.
(4) The recipient's name and identification number, if applicable.
(5) The date of receipt.
(6) The price paid.
(7) The department origin block number where the fish were caught.
(8) The type of gear used.
(9) Any other information the department may prescribe.
(c) The numbered landing receipt forms in each individual landing receipt book shall be completed sequentially. A voided fish landing receipt shall have the word "VOID" plainly and noticeably written on the face of the receipt. A voided fish landing receipt shall be submitted to the department in the same manner as a completed fish landing receipt is submitted to the department. A fish receiver who is no longer conducting business as a licensed receiver shall forward all unused landing receipts and landing receipt books to the department immediately upon terminating his or her business activity.

2. *Fish and Game Code 8050*

(a) In addition to the receipt required in Section 8043, every person licensed under Article 7 (commencing with Section 8030), and any commercial fisherman who sells fish to persons who are not licensed under Article 7 (commencing with Section 8030), and any person who deals in fresh or frozen fish for profit, shall keep accounting records in which all of the following shall be recorded:
(1) The names of the different species.
(2) The number of pounds sold, distributed, or taken of each different species.
(3) The name of the person to whom the fish were sold or distributed.
(4) The name, address, and phone number of the seller or distributor.
(5) The date of sale.

(6) The price paid.
(7) The intended use.
(b) Accounting record information required by this section that is transmitted from any person identified in subdivision (a) to any business that deals in fish for profit shall be in the English language.
(c) The accounting records shall be maintained by both buyer and seller for a period of three years and upon request, shall be open for inspection during normal business hours by the department. The accounting records shall be maintained within the State of
California.
(d) The names used for designating the species of fish shall be those in common usage unless otherwise designated by the department.

M. Market Coordinator

It will be necessary for the cooperative to retain an independent individual who can act as the Market Coordinator. This person will be required to have extensive knowledge of wholesale local and foreign abalone markets. This individual will be paid on a percentage basis and will report directly to the cooperative Board of Directors. The Market Coordinator would be required to negotiate and conduct bonded and insured transactions in a fully transparent process that can be audited if necessary.

The Market Coordinator will comply with all Trace Register tracking requirements and will be responsible for entering information into the web based tracking system at the time of a sale and/or transport of abalone.

Recommendations regarding the nature of this position will be informed by the Bren School Group Project regarding the design for the cooperative.

N. Enforcement

There are two levels of enforcement, state and community. By vertically integrating the harvest activity and wholesale marketing of abalone with a cooperative, many state enforcement concerns can be addressed. This cooperative will enforce its Bylaws on its members and also aide and assist in enforcement of state regulations.

O. Code of Conduct

This cooperative's "Code of Conduct" (Figure 4) will also be enforced on its members. Adherence to this "Code" will be a prerequisite for continued membership in the cooperative.

Figure 4: CALAB Code of Conduct

This cooperative prides itself on the high standards of excellence embodied by our operating principles. We expect our members to personify these ideals in their dealing with persons both inside and outside the cooperative. Your signature below indicates that you have read, understand, and agree to abide by the Cooperative's code of conduct on this ____day of ________________, 2010.

1. I will be trained and participate in accurate data collection using protocols approved by the cooperative and the California Department of Fish and Game
2. I will conduct myself in accordance with cooperative bylaws
3. I will conduct myself in a legal fashion. It is my responsibility to know and obey all state laws and regulations in effect while I am fishing.
4. I will report violations of those state laws.
5. I will record all required information into the cooperative Harvest Log accurately and in the required timeframe
6. I will practice good harvesting methods that include but are not limited to:

    a. Measuring before handling and harvesting
    b. Record harvest aggregations according to harvest guidelines set forth by the cooperative
    c. Harvest only legal abalones taken off a rock (no high-grading)
    d. Tag all abalones immediately after leaving the water and being placed on a vessel (no untagged abalones in your fish hold or vessels receiver)
    e. Only harvest abalone on a single species fishing trip
    f. Do not turn over rocks

7. I will conduct myself with integrity, honesty, and respect for others
8. I will conduct myself in a professional manner that casts a positive light on the cooperative

Failure to adhere to Fish & Game Code or the cooperative's Code of Conduct and bylaws will be grounds for losing membership in the cooperative

P. Violations/Sanctions

1. Violations

   It is unlawful for any person to purchase, receive, possess, or sell any abalone, or parts thereof, which were illegally taken in California waters.

   Any violations of abalone fishing regulations should be prosecuted by CDFG to the full extent of the law. It is recommended that infractions of a serious nature (over limits, under sized, out of season, out of area, possession of shucked abalone, buying or selling any fish illegally taken in California waters, or harvesting restricted abalone species) shall result in expulsion from the fishery and/or permanent revocation of all abalone-harvesting privileges.

   All cooperative members will assist CDFG in enforcement efforts. Communication between CDFG enforcement personnel and cooperative members should be promoted with ways and means of enhancing compliance sought.

   Violations of state regulations that lead to permit revocation by the state are grounds for expulsion from this cooperative.

2. Sanctions

   The consequences of lesser infractions which the state allows the cooperative to enforce will be developed in conjunction with CDFG. A complete list of sanctions related to these infractions (i.e. incomplete Harvest Log) will be developed once the cooperative is formed.

Q. Member Capacity Adjustment/Transfer

Initially the cooperative will accept all qualified applicants for membership consideration. Over time the number of members may need to be adjusted as conditions change. Adjusting the fishery's participant capacity would be a function of both the cooperative and CDFG with all decisions reached in consultation between the two. The CDFG will issue transferable permits and the cooperative will allow change by increasing, decreasing, or transferring membership.

The goal is to create a plan that is flexible and easily adaptable, which recognizes that over time a target capacity goal needs to be set. The following background and assumptions were used to develop the capacity scenarios:

1. There were 102 permitted divers when the fishery moratorium was imposed
2. As of January 1, 2009 there are 84 potential cooperative members
   a) 8 divers have passed away
   b) 10 divers have not been located
3. It could be difficult to manage 84 individuals under a cooperative structure
4. State issues transferable permits to all former 96/97 permit holders
5. Cooperative allows membership to persons who have a State permit
6. Cooperative membership requires "capitalization" from member
7. Cooperative membership allows access to allocation controlled by the cooperative
8. The harvest area and the allocation will be small
9. A Memorandum of Understanding (MOU) between CDFG and the cooperative will be negotiated
   a) The recommended initial carrying capacity for SMI is approximately 35 participants because 35 divers landed 90% of the abalone at SMI when the fishery was closed
   b) All changes in capacity will be addressed in consultation with the cooperative, CDFG, and divers entering or leaving the fishery

The following scenarios have been developed as potential methods for decreasing, maintaining, and increasing capacity.

1. How to Decrease Capacity

   Goal: To task the cooperative's Board to develop a formula to set a value for members leaving the cooperative and develop procedures for decreasing state issued transferable permits.

   It is generally agreed that catch share and cooperative share values are fluid and should be determined at the time of its sale or transfer. This value should be determined by the cooperative, a fee based on the TAC, and the investment value of the departing member.

   Assumptions, goals, and objectives:

   a) Keep catch shares equal
   b) Decrease the number of permits so the cooperative is successful
   c) CDFG will agree to shelve permits of divers leaving the fishery to allow the number of permits to decrease
   d) Value of catch shares will be dependent on the market value and size of TAC

e) Permits have an arbitrary value that is outside the control of the cooperative
f) Cooperative investment share value will be determined by cooperative

Under each of the four (4) scenarios listed below it is also assumed that:

a) Transfers in permits/cooperative membership occur in consultation with all parties (state, cooperative, departing diver, and new diver)
b) New diver (seeking transferred permit) meets state criteria and buys permit from departing diver/member
c) New diver contributes capital to cooperative based on recalculated asset value that is a function of the number of members and value of cooperative investment at that time
d) Funding the increased value and capitalization costs is the responsibility of all cooperative members and will be divided equally
e) New diver and cooperative buy back departing members cooperative shares
f) New diver becomes cooperative member with full privileges and access to allocation

Scenario 1: Two for one – until desired number of permits is reached (35)
Scenario 2: Three for one - until desired number of permits is reached (35)
Scenario 3: Four for one - until desired number of permits is reached (35)
Scenario 4: Four for zero - until desired number of permits is reached (35)

2. How to Maintain Capacity

Goal: To task the cooperative's Board to develop a formula to set a value for members leaving the cooperative and develop procedures for maintaining state issued transferable permits.

It is generally agreed that catch share and cooperative share values are fluid and should be determined at the time of its sale or transfer. This value should be determined by the cooperative and fee based on the TAC the investment value of the departing member.

Assumptions, Goals and Objectives:

a) Keep catch shares equal
b) Transfers in permits/cooperative membership occur in consultation with all parties (state, cooperative, departing, and new diver)
c) New diver (seeking transferred permit) meets state criteria and buys permit from departing diver/member

d) New diver contributes capital to cooperative based on recalculated asset value that is a function of the number of members and value of cooperative investment at that time
e) New diver buys out departing member's cooperative shares
f) New diver becomes cooperative member with full privileges and access to allocation

3. How to Increase Capacity

Goal: If a need arises to increase the capacity of the fishery the cooperative will consult with CDFG to determine under what conditions that increase might be considered and what methods would be used for implementation.

R. Enhancement

In the future the cooperative may be interested in economically viable and environmentally sound enhancement programs.

X: COOPERATIVE LEGAL STRUCTURE

The cooperative will meet all the guidelines and requirements set forth by the State of California and the Federal Fishermen's Collective Marketing Act (FCMA). The cooperative's legal structure will be based on articles of incorporation, bylaws, membership applications, and marketing agreements provided by California attorney Kendall L. Manock of Baker Manock & Jensen in consultation with attorney Joseph M. Sullivan of Mundt MacGregor L.L.P.

The cooperative will also take the necessary steps to qualify for the FCMA's limited antitrust exemption. In order to do so it will meet the following four (4) requirements:

1. Association membership must be limited to "fishermen"
2. Association may deal in product of members and nonmembers, but the value of members' product must be greater than or equal to the value of nonmembers' product
3. Association must be operated for the mutual benefit of its members
4. Association members are limited to one vote or dividends limited to 8% per annum

Details regarding federal antitrust issues related to fishermen's cooperative marketing associations can be found in Joseph Sullivan's memo dated March 2, 2009 (Appendix I).

XI: COOPERATIVE ANNUAL EVALUATION AND REPORT

An annual evaluation process will be defined in an MOU and then established to determine the success of the cooperative in fulfilling management objectives.

The Data Coordinator will review comprehensive fishery dependent and independent data along with fishermen's observations to evaluate the health of the resource so the process can:

1. Respond to changing environmental and socio-economic conditions
2. Review the fishery management systems effectiveness in achieving sustainability
3. Involve people in a fair and reasonable manner
4. Provide an opportunity to design methods for direct input from the fishery participants that help prevent or reduce excess efforts
5. Design management measures to provide information needed to evaluate success or failure
6. Rationalize harvest each year based on data from the previous fishing year

A. Annual Fishery Evaluation and Report

According to the MLMA, the purpose of a fishery management program "is to pursue sustainability by achieving a number of objectives, two of which give more detail about sustainability. First, the long-term health of the resource should not be sacrificed for short-term benefits. Second, depressed fisheries are to be rebuilt to the highest sustainable yields allowed by environmental and habitat conditions."

The cooperative will be required to complete an annual report documenting its compliance with the terms and conditions stated by the MOU(s) in place and under which its annual allocation was issued. Another purpose of the report will be to determine how well the cooperative met its goals for the year.

The Data Coordinator in conjunction with cooperative board members will submit a report at the end of each permit year to cooperative members, CDFG, and the Commission. This report will include fishery results from the past year and recommendations for management in the coming year. The report will also evaluate the following areas:

1. Sustainability and Harvest Activity
   a) Recording the number of animals landed
   b) Recording the activity of participants in the fishery
   c) Stock assessment surveys
   d) Effects of management measures on abalone populations and habitats

2. Data collection and research
    a) Data collected (fishery dependent and independent)
    b) Identify steps CDFG and cooperative should take to monitor the fishery and to obtain essential fishery information
3. Fishery dependent data
    a) Market fishery logbooks
    b) Recreational fishery reports (if available)
4. Enhancement
5. Revenue and Expenditures
    a) Market value of the harvest
    b) Breakdown of taxes and fees (collected by CDFG)
    c) Distribution of funds from the taxes and fees (CDFG expenditures)
    d) Data collection costs
    e) Management Costs
        (1.) Expenditures by CDFG
        (2.) Expenditures by cooperative
    f) Cooperative Administrative Costs
        (1.) Trace Register©
        (2.) Data Coordinator
        (3.) Marketing
        (4.) Administrative support
        (5.) Legal
        (6.) Accounting
6. Non-compliance events

Evaluation tools for the annual report would include:

1. Spreadsheets created from fishery data prepared by the Data Coordinator using logbook data
2. Reports by biologists, technicians, and analysts who utilize Geographic Information System (GIS) to show surveyed and fished areas and present the data visually
3. Data analysis and assessment to refine the fishery process and procedures
4. A report from the fishermen containing their evaluation of the harvest strategy, oceanic conditions and the abalone population.
5. Financial reports prepared by a management/accounting firm

Upon evaluation of the above components, the performance of the fishery will be measured by how well the following standards have been met:

1. Providing evidence that population goals at SMI are being met
2. Monitoring biological reference points to detect changes to the population and oceanic conditions
3. Promoting community-based management to sustain spatially intricate, renewable fishery resources
4. Addressing research needs and information gaps as they arise

It may be required to have a compliance audit conducted by a third party that would report the results of the audit directly to CDFG.

REFERENCES

Abalone fishery history and status. (2001). California Department of Fish and Game from http://ftp.dfg.ca.gov/Public/R7_MR/AAG/regulatory_history/

Abalone Recovery Management Plan (adopted by California Fish and Game Commission, December 9, 2005)

Adler, J.H. (2003). Legal Obstacles to Private Ordering in Marine Fisheries. Roger Williams University Law Review, Vol. 8:9

Anderson, L.G. & Holliday, M.C. (2007). The Design and Use of Limited Access Privilege Programs. National Marine Fisheries Service Technical Memorandum, NMFS-F/SPO-86, November 2007

Ault, J. S. & DeMartini, J. D. (1987). Movement and dispersion of red abalone Haliotis rufescens, in northern California. California Fish and Game Bulletin. 73. 196-213.

Butterworth, D., Gorfine, H., Schroeter, S. & Weber, E. (2009). Evaluation of the Red Abalone Stock Assessment by the Review Committee In Support of Deliberations of the Abalone Advisory Group.

California Department of Fish and Game. Commercial Fishing Provisions 95-01 Relative to Abalone Diving (January 1, 1995).

California Department of Fish and Game Memorandum. Milton, J. (2002). Legal opinion regarding recreational preference that governs marine fishery management decisions (in preparation of the Nearshore Fishery Management Plan).

California Department of Fish and Game (2007). The San Miguel Island Red Abalone Resource: Results of a Survey Conducted in Late August 2006.

California Department of Fish and Game Memorandum. Ugoretz, J. (April 2, 2007). Department Policy Regarding Individual Transferable Quota Fisheries.

California Department of Fish and Game Memorandum. (2007). Management of SMI Red Abalone as a Distinct Population.

California Department of Fish and Game Memorandum. (2007). Clarifying the Derivation of Minimum Viable Population (2,000 abalone per hectare) in the Abalone Recovery and Management Plan.

California Fish and Game Commission. (June 18, 1999). Policy on Restricted Access Commercial Fisheries.

Castilla, J.C., et al. (1998). Artisanal ''caletas'' as units of production and co managers of benthic invertebrates in Chile. In: Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. Jamieson, G.S. & Campbell, A. (Eds.). Canadian Special Publication of Fisheries and Aquatic Sciences 125, Guelph, Ontario, Canada, pp. 407-413.

Cope, J.M. & Punt, A.E. In press. Length-Based Reference Points for Data-Limited Situations: Applications and Restrictions. Marine and Coastal Fisheries: Dynamics, Management & Ecosystem Science, from http://www.fisheries.org/mcf/index.html

Deacon, R.T. & Costello, C. (2008). Strategies for Enhancing Rent Capture in ITQ Fisheries, from www.econ.ucsb.edu/~deacon/DeaconCostelloChapter.pdf

Deacon, R.T., Parker, D.P. & Costello, C. (2008). Improving Efficiency by Assigning Harvest Rights to Fishery Cooperatives: Evidence from the Chignik Salmon Cooperative. Arizona Law Review 50(2): 479–510, from www.law.arizona.edu/journals/ALR/ALR2008/vol502.htm

Deacon, R. (2009). Creating Marine Assets: A Greater Role for Property Rights in Marine Resource Management. PERC Policy Series, 43, from http://www.perc.org/articles/article1137.php

Fishermen's Collective Marketing Act of 1934.

Froese, R. (2004). Keep it simple: three indicators to deal with overfishing. Fish and Fisheries *5: 86-91.*

Froese, R., Stern-Pirlot, A., Winker, H. & Gascuel, D. (2008). Size matters: How single species management can contribute to ecosystem-based fisheries management. Fisheries Research 92: 231-241.

Gordon, H. R. & Cook, P.A. (2001). World abalone supply, markets and pricing: Historical, current and future, Journal of Shellfish Research 20-2, pp. 567-570.

Gordon, H.R. & Cook, P.A. (2004). World abalone fisheries and aquaculture update: supply and market dynamics, Journal of Shellfish Research 23-4 pp. 935.

Gorfine, H.K. & Dixon C.D. (2001). Diver behaviour and its influence on assessments of a quota-managed abalone fishery. Journal of Shellfish Research 20-2, pp. 787-794.

Gorfine, H. K. et al. (2001). Triggers and targets: What are we aiming for with abalone fisheries models in Australia? Journal of Shellfish Research 20-2, pp. 803-811.

Guzman del Proo, S.A. (1992). A review of the biology of abalone and its fishery in Mexico. In: Abalone of the World: Biology, Fisheries and Culture (Proceedings of the 1st International Symposium on Abalone. La Paz, November 21-25, 1989) (Eds. Shepherd, S.A., Tegner, M.J. & Guzman del Proo, S.A.), pp. 341-350. Fishing News Books, Cambridge.

Haaker, P.L. et al. (1998). Growth of red abalone, Haliotis rufescens (Swainson), at Johnsons Lee, Santa Rosa Island, California, Journal of Shellfish Research 17-3 pp. 747-753.

Hardin, G. (1968). The tragedy of the commons. Science, 162, 1243–1248.

Hart, A.M. et al. (2008). Digital video surveys of abalone (Haliotis sp.) stocks by commercial fishers in Western Australia. Fisheries Research 93, pp. 305-314.

Hilborn, R. & Walters, C.J. (1992). Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York, 570.

Hilborn, R., Punt, A.E. & Orensanz, J.M. (2004). Beyond band-aids in fisheries management: fixing world fisheries. Bull. Mar. Sci. 74, 493–507.

Hilborn, R., Orensanz, J.M., Parma, A.M. (2005). Institutions, Incentives and the Future of Fisheries. Phil. Trans. R. Soc. B, 360, 47–57.

Hilborn, R. (2007). Moving to Sustainability by Learning from Successful Fisheries, Royal Swedish Academy of Sciences, Ambio Vol. 36, No. 4.

Hines, A.H. & Pearse, J.S. (1982). Abalones, shells, and sea otters: dynamics of prey populations in central California. Ecology, 63, 1547–1560.

Historical Regulations. (2001). California Department of Fish and Game from http://ftp.dfg.ca.gov/Public/R7_MR/AAG/regulatory_history/

Huchette, S.M.H. & Clavier, J. (2004). Status of the ormer (Haliotis tuberculata L.) industry in Europe, Journal of Shellfish Research 23-4 pp. 951.

Jiao, Y., Leaf, R. (In preparation 2009). Improving the Stock Assessment of California Red Abalone at SMI.

Jiao, Y., Rogers-Bennett, L., Crone, P., & Butler, J. (April 2009) Developing a TAC Framework for Red Abalone at SMI. Final Technical Panel Report to Abalone Advisory Group.

Johannes, R.E. (2002). The Renaissance of Community-based Marine Resource Management in Oceania. Ann. Rev. Ecol. System. 33, 317–340.

Johannes, R.E. (1992). 6th FFA Technical subcommittee workshop focus: Decentralized Nearshore Fisheries Management in Oceania. 6th Forum Fisheries Agency Committee.

Johannes, R.E. (1992). Co-operative fisheries management: Major Changes in Training Required for Government Fisheries Personnel. Traditional Marine Resource Management and Knowledge Information Bulletin.

Karpov, K.A., et al. (1998). The red abalone, Haliotis rufescens, in California: importance of a depth refuge to abalone management. Journal of Shellfish Research 17:863–870.

Karpov, K.A., et al. (2001). Interactions among red abalones and sea urchins in fished and reserve sites of northern California: Implications of competition to management. Journal of Shellfish Research 20: pp. 743-753.

Kashiwada, J.V. & Taniguchi, I.K. (2007). Application of recent red abalone Haliotis rufescens surveys to management decisions outlined in the California Abalone Recovery and Management Plan. Journal of Shellfish Research, 26-3, pp. 713-717

Keesing, J.K. & Baker, J.L. (1998). The benefits of catch and effort data at a fine spatial scale in the South Australian abalone (Haliotis laevigata and H. rubra). In: Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management (Eds. Jamieson, G.S. & Campbell, A.), pp. 179-186. Can. Spec. Publ. Fish. Aquat. Sci., 125.

Leaf R., Rogers-Bennett, L., & Jiao, Y. (2008). Exploring the Use of a Size-Based Egg-per-Recruit Model for the Red Abalone Fishery in California. North American Journal of Fisheries Management 28:1638–1647.

Leal, D.R. (2008). A Fisherman's Agreement and Co-op in Yaquina Bay Roe Herring. In Case Studies in Fisheries Self-Governance, Eds. Townsend, R., Shotton, R. & Uchida, H. FAO Technical Paper 504. Rome, Italy, 415–23, from www.fao.org/docrep/010/a1497e/a1497e00.htm.

Marine Stewardship Council. Sustainable Fisheries Goals, from www.msc.org.

Mayfield S., McGarvey R., Carlson, I.J. & Dixon, C.D. (2008). Integrating commercial and research surveys to estimate the harvestable biomass, and establish a quota, for an unexploited abalone population. ICES Journal of Marine Science 65, 1122-1130.

Mayfield, S. et al. (In preparation 2009). Survey estimates of fishable biomass following a mass mortality in an Australian molluscan fishery**.** South Australian Research and Development Institute.

McGarvey, R., et al. (2008). A diver survey design to estimate absolute density, biomass and spatial distribution of abalone. Canadian Journal of Fisheries and Aquatic Sciences, 65:1931-1944.

McLeod, Lubchenco, Palumbi, & Rosenberg. (2005). Scientific Consensus Statement on Marine Ecosystem-Based Management, from www.compassonline.org/pdf/EBM_Consensus_Statement_v12.pdf

McShane, P.E. & Naylor, J.R. (1995). Small-scale spatial variation in growth, size at maturity, and yield and egg-per-recruit relations in the New Zealand abalone Haliotis iris. N. Z. J. Mar. Freshwater Res., 29, 603–612.

McShane, P.E. (1992). Early life history of abalone: a review. In: Abalone of the World: Biology, Fisheries and Culture (Proceedings of the 1st International Symposium on Abalone. La Paz, November 21-25, 1989) (Eds. Shepherd, S.A., Tegner, M.J. & Guzman del Proo, S.A.), pp. 120-138. Fishing News Books, Cambridge.

McShane, P.E. & Smith, M.G. (1988). Measuring abundance of juvenile abalone Haliotis rubra Leach (Gastropoda: Haliotidae); Comparison of a novel method with two other methods. Aust. J. Mar. Freshwater Res. 39, pp. 331–336.

McShane, P.E., Black, K.P. & Smith, M.G. (1988). Recruitment processes in Haliotis rubra Leach (Mollusca: Gastropoda) and regional hydrodynamics in southeastern Australia imply localized dispersal of larvae. J. Exp. Mar. Biol. Ecol., 124, 175–203.

National Research Council. (1999). Sharing the Fish: Toward a National Policy on Individual Fishing Quotas. National Academy of Sciences.

Officer, R.A. et al. (2005). Movement and re-aggregation of the blacklip abalone, Haliotis rubra Leach, after fishing. Journal of Shellfish Research 20-2, pp. 771-779

Officer, R.A., Haddon, M. & Gorfine, H. K. (2005). Distance-based abundance estimation for abalone. Journal of Shellfish Research 20-2, pp. 781-786.

Orensanz, J.M. (Lobo) & Jamieson, G.S. (1998). The assessment and management of spatially structured stocks: an overview of the North Pacific Symposium on Invertebrate Stock Assessment and Management. . In: Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. (Eds. Jamieson, G.S. & Campbell, A.), pp. 441-459. Can. Spec. Publ. Fish. Aquat. Sci., 125.

Parker, D.O., Haaker, P.L. & Togstead, H.A. (1992). Case histories for three species of California abalone, Haliotis corrugata, H. fulgens and H. cracherodii. In: Abalone of the World: Biology, Fisheries and Culture (Proceedings of the 1st International Symposium on Abalone. La Paz, November 21-25, 1989) (Eds. Shepherd, S.A., Tegner, M.J. & Guzman del Proo, S.A.), pp. 384-394. Fishing News Books, Scientific Cambridge.

Parma, A.M. et al (2003). Diving for shellfish and data: incentives for the participation of fishers in the monitoring and management of artisanal fisheries around southern South America. Towards Sustainability of Data-Limited Multi-Sector Fisheries. Australian Society for Fish Biology Workshop Proceedings, Bunbury, Western Australia 23-24 September 2001. Fisheries Occasional Publications No. 5, June 2003, Department of Fisheries, Perth, Western Australia, pp. 8-29.

Ponce-Diaz, G. et al. (1998). Socioeconomic characteristics of the abalone fishery along the west coast of the Baja California Peninsula, Mexico. Journal of Shellfish Research 17-3, pp. 853-857.

Prince, J.D., et al (1987). Experimental evidence for limited dispersal of haliotid larvae (genus Haliotis: Mollusca: Gastropoda). J. Exp. Mar. Biol. Ecol., 106, 243–263.

Prince, J.D., et al. (1988). Confirmation of a relationship between the localized abundance of breeding stock and recruitment for Haliotis rubra leach (Mollusca: Gastropoda). J. Exp. Mar. Biol. Ecol., 122, 91–104.

Prince, J.D. (1989). The fisheries biology of the Tasmanian stocks of Haliotis rubra. PhD Thesis, University of Tasmania, Hobart

Prince, J.D. & Shepherd, S.A. (1992). Australian abalone fisheries and their management. In: Abalone of the World: Biology, Fisheries and Culture (Proceedings of the 1st International Symposium on Abalone. La Paz, November 21-25,1989) (Eds. Shepherd, S.A., Tegner, M.J. & Guzman del Proo, S.A.), pp. 407-426. Fishing News Books, Cambridge.

Prince, J.D. & Hilborn, R. (1998a). Concentration profiles and invertebrate fisheries management. In: Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. (Eds. Jamieson, G.S. & Campbell, A.), pp. 187-196. Can. Spec. Publ. Fish. Aquat. Sci., 125.

Prince, J.D., Walters, C., Ruiz-Avila, R.J. & Sluczanowski, P. (1998b). Territorial user's rights in the Australian abalone fishery. In: Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management (Eds. Jamieson, G.S. & Campbell, A.), pp. 367-375. Can. Spec. Publ. Fish. Aquat. Sci., 125.

Prince, J.D. (2003). The barefoot ecologist goes fishing. Fish and Fisheries, 4, 359-371.

Prince, J.D. (2005). Combating the tyranny of scale for haliotids: Micro-management for microstocks. Bulletin of Marine Science, 76(2): 557–577.

Prince, J.D. (2008). Re-scaling fisheries assessment and management: access privileges, responsibilities and toolboxes. Presentation at Mote Marine Laboratory Fisheries Conference, Summer 2008.

Ramade-Villanueva, M.R. et al. (1998). An evaluation of the annual quota mechanism as a management tool in the Mexican abalone fishery. Journal of Shellfish Research 17-3, pp. 847-851.

Restrepo, V.R., et al. (1998). Technical Guidance on the Use of Precautionary approaches to Implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act Prepared for the National Marine Fisheries Service.

Rogers-Bennett, L. & Pearse, J.S. (1998). Experimental seeding of hatchery-reared juvenile red abalone in northern California, Journal of Shellfish Research 17-3, pp. 877-880.

Rogers-Bennett, L. et al. (2007). Modeling growth and mortality of red abalone (Haliotis rufescens) in Northern California. Journal of Shellfish Research 26-3, pp. 719-727.

Ruddle, K. & Johannes, R.E. (Ed.) (1983) Traditional marine resource management in the Pacific Basin: an anthology. 410p. UNESCO/ROSTSEA Jln. M.H. Thamrin No. 14, Jakarta

Roberts, R. (2005). Trends in world abalone production. PowerPoint presentation. Paua Industry Conference, New Zealand.

Roberts, R. et al. (2007). Viability of abalone (Haliotis iris) stock enhancement by release of hatchery-reared seed in Marlborough, New Zealand. Journal of Shellfish Research 26-3, pp. 697-703.

Shepherd, S.A. & Baker, J.L. (1998). Biological reference points in an abalone (Haliotis laevigata) fishery. In: Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management (Eds. Jamieson, G.S. & Campbell, A.), pp. 235-245. Can. Spec. Publ. Fish. Aquat. Sci., 125.

Shepherd, S.A. & Brown, L.D. (1993). What is an abalone stock: implications for the role of refugia in conservation. Can. J. Fish. Aquat. Sci., 50, 2001–2009.

Shepherd, S.A. & Breen, P.A. (1992). Mortality in abalone: its estimation, variability and causes. In: Abalone of the World: Biology, Fisheries and Culture (Proceedings of the 1st International Symposium on Abalone. La Paz, November 21-25, 1989) (Eds. Shepherd, S.A., Tegner, M.J. & Guzman del Proo, S.A.), pp. 276-304. Fishing News Books, Cambridge.

Shepherd, S.A. & Rodda, K.R. (2001). Sustainability demands vigilance: evidence for serial decline of the greenlip abalone fishery and a review of management. J. Shellfish Res., 20, 829–841.

Shepherd, S.A., Rodda, K.R. & Vargas, K.M. (2001). A chronicle of collapse in two abalone stocks with proposals for precautionary management. J. Shellfish Res., 20, 843–856.

Shepherd, S.A. (1986). Studies on Southern Australian abalone (genus haliotis) VII. Aggregative behavior of H. laevigata in relation to spawning. Marine Biology 90, pp. 231, 236.

Sullivan, J. M. (2000). Harvesting Cooperatives and U.S. Antitrust Law Recent Developments and Implications. Proceedings of the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade. July 10-14, 2001, Corvallis, Oregon.

Taniguchi, I., Stein, D., Lampson, K. & Kalvass, P. (2007). The San Miguel Island Red Abalone Resource: Results of a Survey Conducted from July-October 2007.

Technical Panel-Abalone Advisory Group. (February 2009). Draft Overview of Red Abalone Stock Assessment and TAC Considerations for San Miguel Island.

Tegner, M.J. (1989). Population biology of red abalones, Haliotis rufescens, in southern California and management of the red and pink, H. corrugata, abalone fisheries. Fishery Bulletin, U.S. 87:313-339.

Tegner M. J. (2001). Climate variability, kelp forests, and the Southern California red abalone fishery. Journal of Shellfish Research 20-2: pp. 755-763.

Townsend, R., Shotton, R. & Uchida, H. (Eds.) (2008). Case studies in fisheries self-governance. FAO Fisheries Technical Paper. No. 504. Rome, FAO. 451p.

Trace Register (2009). Using Digital Supply Chain Traceability to Halt Illegal, Unreported, and Unregulated (IUU) Fishing, from www.traceregister.com.

Troynikov, V.S. & Gorfine, H.K. (1998). Alternative approach for establishing legal minimum lengths for abalone based on stochastic growth models for length increment data. Journal of Shellfish Research 17-3, pp. 827-83.

Vilchis, L. Ignacio. (2005). Ocean warming effects on growth, reproduction, and survivorship of southern California abalone. Ecological Applications, 15(2), 2005, pp. 469-480

Weber, M. & Heneman, B. (1998). Guide to California's Marine Life Management Act. Common Knowledge Press.

Walters, C. (1986). Adaptive Management of Renewable Resources.
The Blackburn Press.

Walters, C. et al. (1998). Management options for the South Australian rock lobster (Jasus edwardsii) fishery: a case study of co-operative assessment and policy design by fishers and biologists. In: Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. (Eds. Jamieson, G.S. & Campbell, A.), pp. 377-384. Can. Spec. Publ. Fish. Aquat. Sci., 125.

Wilen. (2002). Property Rights and the Texture of Rents in Fisheries. Paper presented at PERC's 13th Political Economy Forum.

Worm, B. et al. (2009). Rebuilding Global Fisheries. Science 325, 578.

APPENDIX A: FISH AND GAME COMMISSION POLICIES REGARDING RESTRICTED ACCESS TO COMMERCIAL FISHERIES

From the California Marine Life Management Act - Appendix D - 1999

The policies in this document provide a source of information for the public and a guide for the Commission and Department in preparing and reviewing legislation, regulations, or policies that propose to restrict access to commercial fisheries. The development and adoption of these policies do not represent an initiative to apply restricted access approaches to all California fisheries. The objective is primarily to guide the Commission and Department in responding to requested for restricted access programs.

1. RESTRICTED ACCESS AS A MANAGEMENT TOOL

The Global Context. Virtually every modern fishery faces-or has faced-similar intractable management problems. Because these problems recur in so many dissimilar fisheries, it is clear that they are not caused by the biology of the species harvested, nor do they depend on the type of gear or size of vessel employed by harvesters.

The one factor common to all of these fisheries is that the fishery resources are available to anyone who wants to pursue them. Once a fisheries management authority specifies the total catch, the season length, and the allowable gear, every fisherman competes with every other fisherman to catch as much as possible in the shortest time possible. In some fisheries, bigger and faster boats, more electronics, more gear, longer hours each day and fewer days each season are the result as each fisherman rushes to catch more than the other - the "race for fish" so often described in the fishery management and economics literature. In other fisheries, the problem may just be that the number of participants has increased to a level that jeopardizes the economic viability of the fishery. What makes sense for the individual makes no sense in the aggregate because it results in too many vessels, too much gear, too much waste, and too little income for fishermen. Moreover, excess fishing capacity usually leads to overfished populations of fish, which eventually leads to confrontations between fishermen and fishery managers over the status of the resource and the need for more restrictive regulations. Debate then follows over the need for better data.

The race for fish does not result from inadequate biological information. Population surveys, stock assessments and biological samples are important components of sound fishery management, and improving the science on which management decisions are based is always a desirable objective. But management plans based on better biology alone will not solve problems caused by the economics of the harvest system. Economic problems must be addressed directly.

The most effective solutions to these fishery management problems restrict fishing effort in some way so that the "race for fish" is ended. New entry to a fishery is most often restricted by issuing only a certain number of licenses to participate in the fishery. Existing effort in a fishery is usually restricted by limiting the size of the vessel, limiting the size or amount of gear, or directly limiting the quantity of fish that can be landed. Theoretically, the "right" number of licenses fished by the "right" size of vessels using the "right" amount of gear can harvest fish more sustainably and efficiently than the unrestricted fleet.

The problems restricted access programs are meant to address can actually become worse if the programs are poorly designed. Because many restricted access programs have been seriously flawed, some fishermen and others lack confidence that they can work. For example, in setting up restricted access programs, fishery managers have sometimes issued licenses to many more participants than are possible for the fishery to be both sustainable and economically viable for its participants. Clearly, expanding the fleet can have no effect on slowing the race for fish. Just as important, effort restrictions, such as those on the size of vessels or amount of gear, have sometimes been insufficient to restrain fishing power. Finally, managers sometimes address only one dimension of the race for fish by restricting access without also restricting capacity expansion by existing fishermen.

Because these mistakes have been frequent, it is sometimes said that restricted access doesn't work. What does not work is a management system that lacks the clear policies, the will, and the compassion to design and implement restricted access systems that reconcile the need of fishermen to make a living with the need to restrict total harvest. The set of policies in this document are intended to provide guidance on restricted access programs for the Commission, the Department, the fishing industry, and other interested members of the public.

The California Context. Because California historically did not restrict the number or amount of fishing effort allowed to harvest fish, the state's commercial fisheries generally are overcapitalized: they have the physical capacity to exert more fishing pressure than the resources are able to sustain. Loss and degradation of marine and anadromous habitats and other ecological changes have aggravated this condition of excess fishing capacity. The build-up in harvest capacity began with the advent of ocean commercial fishing in the mid-1800's and accelerated following World War II. Vessels became larger and faster, have greatly increased fishing power and hold capacity, and use a wide variety of electronic innovations to find and catch fish. At the same time, increasing knowledge of the behavior of target species have made fishermen increasingly skilled at their trade.

Since the early 1980s, various programs have been implemented, through statute or regulation, to limit the number of commercial vessels or fishermen allowed to use specific types of fishing gear or to harvest specific species or species groups of fishes. These programs have seldom resulted in adequate reduction in the overall fishing capacity for those species. They sometimes have been effective in capping the number of fishery participants; however, an unintended consequence has been a shift in effort from restricted fisheries to open access fisheries that were already fully developed. The lack of consistent policies for guiding the development of restricted access fisheries¤ has resulted in a myriad of laws and regulations that are confusing to the industry, difficult for the Department to interpret and administer, and, in some cases, of questionable benefit to the fishery or the resource they were intended to protect.

Potential Benefits. Properly designed, restricted access programs can enhance the State's ability to manage its commercial fishery resources. Restricted access programs should:

- Contribute to sustainable fisheries management by providing a means to match the level of effort in a fishery to the health of the fishery resource and by giving fishery participants a greater stake in maintaining sustainability;
- Provide a mechanism for funding fishery management, research, monitoring, and law enforcement activities;
- Provide long-term social and economic benefits to the State and fishery participants; and
- Broaden opportunities for the commercial fishing industry to share management responsibility with the Department.

Need for other Fishery Management Tools -- Restricted access programs are an important tool for fishery managers, but they do not eliminate the need for other fishery management measures, such as gear restrictions, time and area closures, size limits, landing quotas, total allowable catches, and related measures. In all fisheries, a minority of vessels or divers catch most of the fish. Statistics show that a major fleet size reduction would be required to significantly reduce the fleet's fishing capacity. A severe restriction in the number of fishery participants, while perhaps contributing to fishery sustainability, can have other consequences that are undesirable: processors may have difficulty acquiring fishery product, for example, and the control of harvest might shift to a few individuals. Laws or regulations that limit the amount of gear that vessels may use or that restrict the amount or size of fish that may be taken are usually important in ensuring that restricted access initiatives achieve the desired benefits.

POLICY 1.1: The Commission and the Department may use restricted access programs as one of a number of tools to conserve and manage fisheries as a public trust resource.

2. GENERAL RESTRICTED ACCESS POLICY/GOALS AND OBJECTIVES OF RESTRICTED ACCESS PROGRAMS

California's fisheries are a public trust resource. As such they are to be protected, conserved and managed for the public benefit, which may include food production, commerce and trade, subsistence, cultural values, recreational opportunities, maintenance of viable ecosystems, and scientific research. None of these purposes need be mutually exclusive and, ideally, as many of these purposes should be encouraged as possible, consistent with resource conservation.

Fisheries are also a finite and renewable resource. If harvest and other human-caused factors affecting their health are not managed, fishery resources may be less than optimally productive or, in the worst case, may suffer serious declines. Therefore, as part of a program of controlling harvest, it is appropriate to control the amount of fishing effort applied in a fishery, including restrictions on the number of individuals or numbers of vessels participating. Restricting access to a fishery has become one of many standard fishery management tools that have been used by public agencies in carrying out their conservation and management responsibilities for publicly held, finite fishery resources.

In general, the goals of restricting access to commercial fisheries are to contribute to the effective conservation and management of the State's marine living resources, provide long-term social and economic benefits to the commercial fishing industry and the State, and retain the public ownership status of those resources. More specifically, the Commission's purposes for restricting access or entry to a fishery are described as being to: 1) promote sustainable fisheries; 2) provide for an orderly fishery; 3) promote conservation among fishery participants; and 4) maintain the long-term economic viability of fisheries. Restricted access programs may be instituted in order to carry out one or more of these purposes in a given fishery.

Promote Sustainable Fisheries. Depending on the fishery, limiting the fishing capacity of the fishery by limiting the number of individual fishermen or vessels may be one means of reducing take in order to protect the fishery resource. In most instances, reducing the number of individuals or vessels alone will not in itself reduce take unless it is accompanied by complementary measures such as trip limits, quotas, seasons, or gear limitations. Together restrictions on access coupled with other measures can be an effective way of controlling effort to protect fishery resources and contribute to sustainability.

Provide for an Orderly Fishery. Extreme overcapitalization can lead to unsafe conditions as part of the competition among fishery participants, as in the case of "derby" fisheries. Properly designed restricted access programs can promote safety in those circumstances. Where fishing grounds are limited due either to geographical factors or fish congregating in small areas where harvest occurs, it may be necessary to limit the number of individuals or vessels involved in the fishery. The herring roe fishery is one example of where restricted access was established primarily for the purpose of maintaining an orderly fishery.

Promote Conservation Among Fishery Participants. Limiting the number of individuals or vessels in a fishery can give those in the fishery a greater stake in the resource, a sense of ownership, and confidence that a long-term opportunity exists in the fishery that usually does not exist in open access fisheries. A well-designed restricted access program can give fishery participants greater incentive to be stewards of that resource and even to invest in rebuilding the fishery (the commercial salmon stamp program, for example). Limiting access can also increase compliance with fishery regulations since an individual with a restricted access permit is much less likely to risk losing the opportunity to participate in that fishery because of a fishery violation.

Maintain the Long-term Economic Viability of Fisheries. To assure the greatest economic benefit to society from the harvest of a public fishery resource, it may be necessary to limit the number of individuals or vessels to assure economically viable fishing operations. When open access contributes to the impoverishment of fishery participants or illegal or unsavory behavior by participants competing for the limited resource, some form of restricted access based on economic viability may be necessary. Any restricted access program established, entirely or in part, for the purpose of economic viability must be crafted to avoid restricting access more than is necessary.

POLICY 2.1: The Commission may develop restricted access programs for fisheries that retain the public ownership status of the resource for one or more of the following purposes:

1) to promote sustainability;
2) to create an orderly fishery;
3) to promote conservation among fishery participants;
4) to maintain the long-term economic viability of fisheries.

3. DEVELOPMENT AND REVIEW OF RESTRICTED ACCESS PROGRAMS

Participation of Stakeholders in Program Development. Restricted access programs should be developed with substantial support and involvement from stakeholders. Indeed, many of California's current restricted access programs were drafted by, or with considerable input from, the affected fishermen (the salmon, herring, Dungeness crab, and sea urchin fisheries, for example). Programs in which fishery participants and others have a substantial role in the design benefit from their knowledge of both the resource and the business aspects of the fishery. Such programs are also more likely to enjoy the support of fishery participants during implementation. Furthermore, any restricted access program must be developed consistent with the stakeholder participation requirements of Section 7059 of the Fish and Game Code.

Programs Specific to the Needs of the Fishery. Standardization in the elements of restricted access programs is a laudable goal and could help reduce some of the complexity fishermen and the Department are faced with when dealing with different requirements for different fisheries. However, the overriding concern is that each restricted access program meets the needs of its particular fishery.

Each of the existing restricted access programs in California fisheries was designed to meet the needs of a particular fishery. As a result of periodic reviews of those programs, it may be possible to reduce some of the complexity that has resulted. However, a program should not be revised solely for the purpose of uniformity or consistency if there is a sound basis for the unique features of the program.

Program Review. Restricted access programs need periodic review for possible revision. Restricted access programs should be reviewed periodically by the Department and fishery participants in the particular fishery to determine whether the program still meets the objectives of the State and the needs of the fishery participants. For the statutorily created restricted access programs, this review should take place preceding the expiration ("sunset") dates when the law is under consideration for extension. In addition, this restricted access policy should be reviewed at a regularly scheduled Commission meeting at least once every four years following its adoption.

POLICY 3.1: Restricted access programs shall be developed with the substantial involvement of participants in the affected fishery and others, consistent with the stakeholder participation requirements of Section 7059 of the Fish and Game Code, and shall balance the specific needs of the fishery with the desirability of increasing uniformity among restricted access programs in order to reduce administrative complexity.

3.2: Each restricted access program shall be reviewed at least every four years and, if appropriate, revised to ensure that it continues to meet the objectives of the State and the fishery participants. Review of each restricted access program shall occur at least as often as the particular fishery is reviewed in the annual fishery status report required by Section 7065 of the Fish and Game Code. The general restricted access policy should be reviewed at a regularly scheduled Commission meeting at least once every four years following its adoption.

4. ELEMENTS OF RESTRICTED ACCESS PROGRAMS

Categories of Restricted Access Fisheries. Existing restricted access programs in California generally are based on target species or species groups of the fishery. The Commission expects that most new restricted access programs will follow that pattern.

Another option that may be appropriate for some fisheries, or groups of fisheries, is basing the restricted access system on gear type. Sixteen species or species groups of fishes comprise 90 percent of the State's commercial fish landings, although only a relatively few basic gear types produce the entire catch. As a means to minimize the number of programs and provide greater flexibility for fishery participants, the Commission and Department could base each restricted access program, first, on the gear type and then, if necessary, on endorsements for the species or species groups that are the target of that gear type. Where possible, the entire range of species (i.e., multi-species, ecosystem approach) contacted by a particular gear type would be included in the same program.

Additional flexibility would be provided in instances in which a fishery participant converted a restricted access permit from one gear type to another. Whether such conversions are allowed would be decided on a fishery-by-fishery basis depending on whether the conversion is consistent with the State's sustainable fisheries policies and the objectives of the two restricted access programs involved.

Each restricted access program should take into account possible impacts on open access fisheries and on other restricted access fisheries.

Fishery Capacity Goals and Means to Achieve Capacity Goals. Because a primary purpose of restricted access programs is to match the level of effort in a fishery to the health of the fishery resource, each restricted access program that is not based on harvest rights (see section on harvest rights) shall identify a fishery capacity goal intended to promote resource sustainability and economic viability of the fishery. Fishery capacity goals can be expressed as some factor or combination of factors that fairly represents the fishing capacity of the fleet. These factors may include the number of permitted fishery participants, number of permitted boats, net tonnage of the permitted fleet, amount of gear used in the fishery, and cumulative hold capacity. Fishery capacity goals should be based on such biological and economic factors as what is known about the size and distribution of the target species, historic fleet size or harvest capacity, and distribution of harvest within the current fleet. Conflicts with other fisheries or ocean interest groups and economic conditions (current and future) within the fishery may also be factored in to such determinations. Depending on the fishery, the fishery capacity goal may be expressed as a single number or as a range.

The preferred approach to determining the capacity goal is to conduct a biological and economic analysis of the fishery. The analysis should consider the probable level of resource sustainability and the impact of various fleet capacities on the fishery and local communities. When such an analysis is not feasible, the Commission, Department, and stakeholders should work together in reviewing available information to arrive at a reasonable capacity goal for the fishery.

Capacity goals should be included in each restricted access program review. A fishery capacity goal will not be useful in managing effort in a fishery unless the restricted access program includes mechanisms for achieving the goal. If the fishery is overcapitalized and above its fishery capacity goal, there must be a system to reduce capacity as a basic requirement of the restricted access program. If the fishery is below its capacity goal, there must be a method to increase participation. In fisheries that are above their fishery capacity goals, transfers of permits should be allowed only if they are consistent with the system for achieving the fishery capacity goal (see Permit Transfers section).

In restricted access fisheries in which the permit is vessel based, the system for achieving fishery capacity goals must include a means of comparing and controlling the fishing power of individual vessels. Without that ability, the system controls only one aspect of fishery capacity-the number of vessels-without providing a means to manage the fishing power of those vessels (see policies on Permit Transfers and Replacement Vessels). The system may be based on factors such as vessel length, displacement, horsepower, hold capacity, or allowable amount of gear.

There are several options available to reduce the number of permits to meet fishery capacity goals. A few examples include:

- Attrition - permit reduction when permit holders fail to renew their permits - has contributed to reducing effort in some fisheries. That process is slow, however, and only occurs when the outlook for the fishery is so poor that the permit has little value.
- "Two-for-one" or similar requirements in transfer of permits have been used in several fisheries to reduce capacity and is effective if there is an active market for permits.
- Annual "performance" standards can be required of each permit holder. For example, a minimum number of landings could be required to qualify for permit renewal. This approach may be appropriated in some fisheries, although it can artificially increase effort.
- Permit or vessel buybacks have been used in a few fisheries and being explored for others in the United States. California's experience with this system is limited to nearshore set gill nets in Southern California. Buyback programs have been funded by both industry (through permit transfer fees, landing fees, special permit fees, etc.) and the public.

POLICY 4.1: Each new restricted access program shall be based either on one or more species or species groups targeted by the fishery or on a type of gear. In programs based on a type of gear, an endorsement may be required for one or more species or species groups targeted by the gear type. Each restricted access program should take into account possible impacts of the program on other fisheries.

4.2: Each restricted access program that is not based on harvest rights shall have a capacity goal. The Commission, Department, and stakeholders will use the best available biological and economic information in determining each capacity goal.

4.3: Each restricted access fishery system shall have an equitable, practicable, and enforceable system for reducing fishing capacity when the fishery is exceeding its participation goal and for increasing fishing capacity when the fishery is below its fishery capacity goal.

4.4: In fisheries that exceed their fishery capacity goals, permit transfers will be allowed only if they are consistent with the means for achieving the fishery capacity goal.

5. PERMITS

Issuance of Initial Permits. The public will be given reasonable notice of intent to limit access to the fishery. A legislative bill may serve as an initial notice of intent, or the Commission may take an action that serves as a notice of intent.

The Commission may set a Control Date for determining qualification for a restricted access program. Some level of fishery participation may be required to qualify for an initial permit. Fishery qualification can be based upon fishery participation during a period of time preceding notification of intent. In determining criteria for qualifying for the program, the Commission may consider the balance of gear types currently or historically relying on the fishery or the specialty markets or niches that the fishery was intended to serve. Fish landing data maintained by the Department shall be the basis for documenting fishery participation. Affidavits of fishery participation, or medical statements of inability to meet qualification standards shall not be accepted unless a system for considering exceptions, consistent with Policy 5.1, is included in the design of the restricted access program. Vessels under construction or inoperable during the qualification period shall not be considered for a permit.

California has had a practice-shared with other states, the Federal government, and other nations-of giving preference for issuing permits into a restricted access fishery to fishermen or vessels with past participation in that fishery. The practice has meant, as well, that permits generally have been issued to licensed California commercial fishermen rather than to nonfishermen or persons not licensed in the State. The practice is a fair means to assure that those who rely on that fishery or who have invested in that fishery can remain in the fishery. In determining priorities for the issuance of permits in a restricted access fishery, first priority for permits shall be given to licensed commercial fishermen/vessels with past participation in that fishery. Among fishermen or vessels with past participation in the affected fishery, preference for permits may be based on factors such as years of participation in the fishery or level of participation (landings). Second priority for permits may be based on such factors as crew experience, number of years in California fisheries, or participation in fisheries similar to that for which a program is being developed. (An example of a similar fishery being considered for eligibility for a permit was when displaced abalone divers were added to those eligible for any new sea urchin permits.) Drawings or lotteries for permits should only be used when two or more applicants have identical qualifications (for example, the same number of points for eligibility for a herring permit).

When initiating a restricted access program with vessel-based permits, designing a formula for deciding which vessels qualify that is equitable but does not increase the number of permits or the amount of effort already in the fishery is difficult but necessary; without such a formula, the program can easily exacerbate the fishery's problems. The Commission's policy on this issue has three elements. First, the policy for all restricted access fisheries begins with the premise that initiating a restricted access program must not increase the recent level of fishing effort. Second, the default approach in designing a new program will be to issue initial permits only to the current owners of qualifying vessels. Third, in order to meet the needs of a particular fishery, it may be desirable to modify the approach of giving permits only to current owners of qualifying vessels.

Such exceptions would be decided fishery by fishery, but in no case would the formula allow increasing the recent level of effort.

A permit issued for dive, gill net, and some trap fisheries shall be issued to qualifying fishermen. A permit issued for a boat-based fishery may be issued to, 1) an individual who owned a qualifying vessel during the period in which the vessel qualified, and 2) 20-year commercial fishermen (as provided in Section 8101 of the Fish & Game Code).

Issuance of New Permits. In the case of restricted access fisheries that are below their fishery capacity goals, new permits may be issued. The factors used to determine priority for issuance of new permits may be the same as for the issuance of initial permits.

Permit Renewal and Duration. Permits are renewable annually upon application and payment of the permit fee if the permit holder meets the requirements of the restricted access program. Permits may be renewed annually for the life of the restricted access program. Limiting participation to a period less than the actual life of the limited access program has several drawbacks. First, it could eliminate incentive for conservation among permit holders if they know that their participation in the fishery will be limited. Second, a limitation on permit life would tend to discourage investment and diminish the value of existing investment (vessels, for example) in the fishery. New investment in many fisheries is needed for safer, more fuel efficient vessels, for equipment to maintain quality of the catch, and for changing gear. That will be discouraged if the duration of the permits is limited.

Substitutes. Each restricted access program with fishermen-based permits should determine whether substitutes for the permit holder will be allowed and, if so, in what circumstances and for what length of time. One option is that the permit holder must be present. Some programs have allowed temporary use of the permit by another in the case of death or disability of the permit holder.

POLICY 5.1: The Commission will give adequate public notice of intent to establish a restricted access program. The Commission may set a Control Date for determining qualification for a restricted access program. A new restricted access program shall not allow fishing effort to increase beyond recent levels. Some level of fishery participation may be required to qualify for an initial permit. Fishery qualification can be based upon fishery participation during a period of time preceding notification of intent, or on other factors relevant to the particular fishery. Affidavits of fishery participation, or medical statements of inability to meet qualification standards shall not be accepted. Vessels under construction or inoperable during the qualification period shall not be considered for a permit.

5.2: New permits in a restricted access fishery shall only be issued when the fishery is below its fishery capacity goal.

5.3: Restricted access fishery permits shall be of one year duration and are renewed upon annual application and payment of the permit fee and shall be valid, provided they are annually renewed and the permit holder meets the requirements of the restricted access program, for the life of the program.

5.4: Each fisherman-based program shall determine in what circumstances, if any, a substitute may fish the permit.

6. PERMIT TRANSFERS

Permits within a restricted access program may be transferable or not, depending on the fishery. California currently manages some restricted access fisheries in which the permits are not transferable. Although non-transferable permits may be appropriate for some fisheries, the Commission expects that the trend will be toward transferability. First, permit transferability can and should be used as part of the mechanism for reducing capacity in a fishery that is above its capacity goal. Second, permit transferability allows for new entry into a restricted access fishery, particularly for younger fishermen or crew. Third, permit transferability protects part of an individual's investment in a fishery.

In California, as in nearly all states and federally managed fisheries, most limited access permits are transferable. Although a number of limited access fishery programs in California initially did not allow for permit transfers, these systems were found unworkable. Permit holders, even the aged, the sick, or those seeking to leave the fishery, held on to their permits, attempting in many instances to have the permit fished by another, non-permitted, individual. Non-transferability encouraged some fishery participants to work around the program rather than within it. Moreover, fishing vessels, particularly the larger ones or those built for a specific fishery, were rendered useless if there was no permit to go with them at the time of sale. For fishermen, as is the case with small business owners or farmers, their retirement funds are derived from the sale of their business, which in the case of a fisherman may be his/her vessel.

Fully transferable permits in restricted access programs have been criticized for the following reasons: 1) sales of permits on the open market can make the cost of entry into a fishery for young fishermen or crew extremely expensive and does not assure that the most deserving individuals obtain permits; 2) sales of permits on the open market can result in windfall profits for those individuals who were initially issued a permit by the State and whose investment in the permit has only been the payment to the State of the permit fee; and 3) sales of permits on the open market can result in permits going to more active participants or to larger vessels deploying more fishing effort thereby increasing the fishing effort or capacity of the fleet. To the extent that these criticisms are valid, they can, and currently are in California, being addressed through conditions placed on permit transfers.

In order to prevent an increase in fishing power, in California's salmon limited entry program, permits are transferable with the fishing vessel at the time of sale or to another vessel of equal or less fishing capacity, under specified conditions. In the herring fishery, where the permit is to the individual rather than the vessel, permit transfers may only be made to a fishing partner or an individual holding a maximum number of points in that fishery, with points based on years of crew experience and years in California fisheries. This limitation on transfers is intended to give an advantage to those who have spent time in the fishery. Thus, those deserving of a permit are given a preference. By limiting the market for permit sales, the cost of entry is lower than it would be if the permits were available on a wide open market.

It is also possible to prevent increases in fishery capacity and reduce speculation in permits by setting fishery participation criteria in selected qualifying years for a permit to be transferable, or by requiring that the permit be held for some minimum number of years before it can be sold.

It is possible, as well, for the State and other participants in the fishery to benefit from the sale of permits through transfer fees or two-for-one permit transfer requirements. In California, there are transfer fees in some restricted access fisheries where the fees exceed the cost of administering a change in the permit. A transfer fee addresses the concern that permit holders may be making windfall profits from the sale of permits and can allow the State to share in the economic benefits of good conservation and management measures. Other participants in the fishery can benefit if the permit transfer fees are re-invested in the fishery, such as through a permit buyback program. Both the State and participants in the fishery can benefit through two-for-one permit transfer requirements if they are used to help reach a fishery capacity goal.

POLICY 6.1: Restricted access permits may be transferable. In fisheries in which the permit is transferable, transfer may be subject to conditions that contribute to the objectives of the restricted access program. In new restricted access programs, permit transfers will not be allowed unless a fishery capacity goal and a system for achieving that goal is part of the restricted access program. In existing restricted access programs, the objective is to review and revise those programs to include fishery capacity goals and systems to achieve those goals. A restricted access program may include a fee on the transfer of permits, in excess of actual administrative costs for the permit change, to offset other costs involved in the conservation and management of that fishery.

7. VESSEL ISSUES

Vessel Retirement. All vessel-based restricted access programs should provide for the voluntary retirement of commercial fishing vessels so that these vessels are no longer eligible to compete with permitted vessels in future years. Any vessels requested by the owner to be retired will be permanently identified on Department commercial fishing vessel registration documents. Permits from retired vessels may be allowed to transfer to replacement vessels within one year of retirement provided the replacement vessel is of equal or lower fishing capacity or to a larger vessel if the restricted access program provides for vessel upgrades (see section on vessel upgrades).

Replacement Vessels. Replacement vessels of the same or lower fishing capacity as the permitted vessel will be allowed only if the permitted vessel is lost, stolen, or no longer able to participate as a commercial fishing vessel, as shown on State or government documents, or other sources of information that the Department might consider. This requirement is necessary to preclude effort shift to open-access and other restricted access fisheries. Replacement vessel determinations will be made by the Department. The ownership of the replacement vessel, as shown on government documents, shall be same as the permitted vessel.

Vessel Permit Upgrades. Fishermen who hold vessel permits may want the option of acquiring a larger or more efficient vessel and transferring their existing permits or acquiring and adding new permits to the new vessel. The concern with allowing fishermen to upgrade their vessels is that by doing so the overall capacity of the fleet to catch fish increases, which should be allowed only to the extent that it is consistent with the fishery capacity goal. To offset this increase in fleet harvest capacity in fisheries that are above their fishery capacity goal, a permit consolidation process is needed whereby two or more permits can be combined to allow for the permitting of a single larger vessel. This is not a new concept in restricted access programs elsewhere. The Pacific Fishery Management Council, for example, uses a formula based on vessel length and capacity that allows for combining permits to allow for larger vessels in the groundfish fishery. In the California salmon fishery, vessel length is used by the Salmon Review Board in approving or denying vessel transfer requests for vessels in the 20- to 40-foot range.

Support Vessels. In some fisheries, the use of support vessels can substantially increase the available fishing power of the fleet. In such restricted access fisheries with vessel-based permits, only vessels with a permit for that fishery should be allowed to support fishing operations of other permitted vessels. Non-permitted vessels shall not be allowed to attract fish for permitted vessels or to receive fish from permitted vessels for landing. In programs in which the permit is fisherman based, the use of support vessels may be allowed if they do not create significant enforcement problems or significantly add to the capacity of the fishery, but a registration fee may be required that is the same as the annual permit fee paid by a fishery participant.

POLICY 7.1: Vessels requested to be retired by the vessel owner will no longer be eligible to participate in commercial fisheries in California.

7.2: Replacement vessels of the same or lower fishing capacity as the permitted vessel will be allowed only if the permitted vessel is lost, stolen, retired, or no longer able to participate as a commercial fishing vessel.

7.3: Each restricted access program that allows for vessel permit transfers may allow for vessel upgrades, provided a permit consolidation/vessel retirement process consistent with the fishery capacity goal is made part of the program.

7.4: A restricted access program may prohibit the use of support vessels or require that they be permitted in the fishery or that they pay a fee comparable to the permit fee.

8. HARVEST RIGHTS

Background. Harvest rights, often called individual transferable quotas (ITQs), involve the assignment of the exclusive rights to harvest a share of the annual total allowable catch (TAC) in a fishery. Harvest rights systems are a form of restricted access programs in that participation in the fishery is restricted to those who own quota shares. Setting TACs has been a key element in determining quota shares. The State or nation retains ownership of the fisheries resource. In most cases, individual quota systems have been implemented in fisheries with previously established limited entry programs. These individual quotas can be allocated for specific time periods, but most often are allocated in perpetuity. Individual quotas are often allocated for specific geographic areas such as the International Pacific Halibut Commission's zones. Usually, individual quotas are fully transferable (buy, sell, lease) to allow quota owners to optimize their business activities. Transferability of quota shares allows fishermen to move between fisheries. In exchange for this exclusive harvest right, quota owners usually are required to pay the costs of management, enforcement, and research. This cost recovery often leads to increased involvement of industry in research and management.

Harvest rights have usually been allocated to vessel owners. In some fisheries around the world quotas have also been allocated to communities, processors, and fishermen's organizations. Limits on the amount of quota harvest rights each entity can hold are set to prevent excessive aggregation. Aggregation limits currently range from 0.5 percent in Alaska's halibut fishery to 35 percent in some New Zealand offshore fisheries.

Similar management systems have been used to allocate fishing gear units instead of shares of a TAC. A tradeable lobster trap certificate program developed by fishermen in the southeastern United States is an example.

When these restricted access policies were adopted (1999) industry comment was negative in regard to harvest rights systems. Nonetheless, these programs have become a tool for managing fisheries in various parts of the world, with the herring-roe-on-kelp fishery in California being one example. This policy acknowledges the existence of this tool as well as the complex issues that must be dealt with in developing any harvest rights program. The Commission may consider recommending development of a harvest rights program after careful consideration of stakeholder input.

The first 15 years of experience with individual quota management has shown that they end the race for fish and provide incentives to fishermen to change their business to maximize revenues and minimize costs. However, individual and community transferable quota systems have been controversial in the United States. In the Sustainable Fisheries Act of 1996, Congress placed a four-year moratorium of implementation of new ITQs and instructed the National Academy of Sciences to conduct a thorough study. In December 1998, the NAS study recommended that Congress end the moratorium.

Numerous issues have arisen when individual quotas are implemented and need to be considered:

1. **Allocation of Initial Quotas.** This usually, but not always, has been based on historical catches and/or vessel fishing power. The NAS study recommends that alternative methods of initial allocation be considered in addition to catch histories. Who receives the allocations (fishermen, processors, communities, tribes, etc.) must be determined and other issues resolved. Will initial allocation be free? Will the harvest right be for a certain time or perpetuity? Who is and is not eligible to obtain quota?
2. **Catch Histories.** If initial harvest rights are based to some degree on catch histories, accurate individual vessel or fisherman landings data are needed.
3. **Transferability**. The degree to which quotas are transferable (buy, sell, lease, "fishing on behalf of") must be determined.
4. **Total Allowable Catches.** Assuming individual quotas are a percentage of the TAC, in order to determine how much actual quota each quota owner may harvest, a TAC will have to be set. Setting TACs requires high quality resource assessment information and scientifically sound estimates of sustainable yields.
5. **Aggregation Limits.** Limits on the amount of quota an individual, company, community or other entity may hold needs to be considered, perhaps on a fishery by fishery basis.
6. **Enforcement and Monitoring.** Emphasis would likely shift towards enforcement methods to prevent quota holders from under-reporting their catches. Methods used elsewhere include increased record keeping/tracking of catches, limiting number of landing ports, and increased use of industry-funded monitors at landing ports.
7. **Cost Recovery.** Most individual quota systems include, at a minimum, methods for having quota owners pay the cost of managing the system.
8. **Processor-Fishery Participant Relationships.** Depending on who winds up owning the harvest right, this relationship might change. Past experience shows that the quota owner will have increased influence on fishing decisions.
9. **Quality Considerations.** Early experience with individual quotas shows a consistent trend towards maximizing quality to maximize prices received. This could affect the timing and location of fishing and the other types of regulations needed.

POLICY 8.1: It is the policy of the Commission that harvest rights systems such as individual transferable quotas may be considered only after careful consideration of stakeholder input. In establishing such management systems the State should consider:

(1) fair and equitable initial allocation of quota shares which considers past participation in the fishery,
(2) resource assessment for establishing total allowable catch estimates,
(3) fishery participation goals and aggregation limits,
(4) cost recovery from quota owners,
(5) quota transferability and,
(6) recreational fisheries issues.

9. ADMINISTRATION OF RESTRICTED ACCESS PROGRAMS

Administration. Administrative costs should be minimized by requiring easily understood regulatory or statutory language including a minimum of exceptions to the main provisions. The use of review or advisory boards may be considered on a program-by-program basis. Board members should be reimbursed for travel and per diem expenses. The total cost for administration of each a program should be borne by that program.

The Department will determine what unit is responsible for program administration and made all determinations relating to vessel fishing capacity.

Cost Accounting. Fees collected from restricted access initiatives should, for cost accounting and reporting purposes, be deposited in a single, dedicated Restricted Access Fishery Account within the Fish and Game Preservation Fund. Charges would be made against the account for direct restricted access program support. A fund condition and activity report should be published annually and include the amount of funds received from each restricted access fishery and the distribution and expenditure of those funds.

Enforcement. Restricted access programs should provide specific disincentives for violations of pertinent laws and regulations. Provision for a Civil Damages schedule, pursuant to regulations of the Commission, can serve in this regard. Because restricted access programs confer benefits to permit holders that are denied to those not in the fishery, penalties should be high for violations of the provisions of restricted access programs.

Restricted access programs should minimize enforcement costs. New technologies such as satellite-based vessel tracking are available and can be required of commercial fisheries that operate under Federal fishery management plans. Commission authority to require such technology, if deemed desirable, should be a part of any legislation or regulation creating a restricted access fishery. Wildlife protection staff will be responsible for monitoring the vessels and enforcing the pertinent laws and regulations. Enforcement costs for restricted access fisheries should be borne by the restricted access programs.

POLICY 9.1: Administrative costs shall be minimized, and those costs shall be borne by the respective programs. Review or advisory boards may be considered on a program-by- program basis. The programs shall be administered in their entirety within an existing department unit.

9.2: Fees collected from restricted access initiatives may, for cost accounting and reporting purposes, be deposited in a single, dedicated Restricted Access Fishery Account within the Fish and Game Preservation Fund. A fund condition and activity report should be published annually.

9.3: Restricted access programs should provide specific disincentives for violations of pertinent laws and regulations. Enforcement costs of restricted access programs should be minimized through the use of new technologies or other means.

APPENDIX B: ALTERNATIVE 8

From the Abalone Recovery Management Plan – Section 7.3.8 - December 2005

The alternative allows the Commission to consider abalone (*Haliotis spp.*) fisheries in specific locations that have partially recovered prior to achieving full recovery as defined in the ARMP. This alternative would be implemented initially for red abalone at San Miguel Island using a reduced density criterion. It recognizes that viable abalone populations currently exist and that a broad size range of abalone is present at San Miguel Island. It also recognizes that densities of abalone appear to be above the Minimum Viable Population (MVP) level exists at San Miguel Island and the fact that no-take reserves implemented after the fishery closure will help to ensure continued abalone populations. Other areas, such as the Farallon Islands, may be considered once data are available to show the acceptable density criterion has been met and the fishery at San Miguel Island proves to be practicable.

The alternative allows fishing prior to achieving the Recovery Criterion 3 (three-quarters of the recovery areas achieving a specified density). In this alternative, fisheries may be considered in individual areas that show a broad size range and an average abalone density above an established MVP level. The initial abalone density to open a fishery would be developed using sound scientific data and following standard fisheries management guidelines. This number would be based in particular on the most recent San Miguel Island abalone density surveys. If populations drop below MVP levels, the fishery would be closed and reevaluated.

Under this option data collection would continue in the fished area to determine whether populations were stable, increasing, or decreasing. An independent contractor would develop an overall management plan and review data collected each year to make recommendations on any changes to the fishery. Guidelines governing the contractor's responsibilities will be developed jointly by the Department and potential fishery participants with approval by the Commission. Management recommendations made by the contractor would be reviewed by the Department prior to potential Commission action. cooperative efforts for data collection would include fishery participants to maximize the amount of information available.

If this alternative is selected, strict guidelines for a limited fishery must be implemented to insure that overall recovery continues in both the fished and unfished areas. Several implementation options would be considered in order to ensure a viable and well managed fishery. Specific regulations would be developed in consultation with the potential fishery participants once this option was adopted. The following is a summary of some fisheries management measures that would need to be developed (others measures, in addition to these, may also be necessary):

- Fishery Opening Density Level - This level would be set by the Commission at a level above MVP and would be based upon recent density surveys at proposed harvest areas.

- Total Allowable Catch (TAC) - The TAC would be determined based upon estimates of abalone abundance above minimum legal size. The TAC would be a fraction of this amount to maintain both a sustainable population and an economically viable fishery.

- Recreational and Commercial Allocation - The TAC would be allocated between recreational and commercial take based upon pre-determined criteria established by the Commission. Included in this would be discussions on the number of participants allowed into the fishery. Priority for participation in the commercial fishery shall be given to those persons who held a commercial abalone permit during the 1996-1997 permit year [Title 14, subsection 5522(e)]

- Regulatory Measures - Specific regulations would be developed cooperatively with potential fishery participants in order to ensure a well managed fishery. Potential regulatory measures include the following, but would be determined as part of the normal regulatory process:

    - Larger than historic size limits - An equal size limit for commercial and recreational take would be set above the historic size limit. This would help ensure an increased abundance of breeding abalone when reproduction occurs.
    - Restricted seasons - A seasonal fishery may provide for ease of enforcement and allow review of biological survey data to provide management recommendations in the off season. It could also allow for undisturbed reproductive periods.
    - Restricted landing locations - This would help prevent illegal activities by limiting the number of areas where abalone could be landed.
    - Tag requirement for all commercial and recreational abalone taken - By individually marking abalone at point of collection potential illegal take would be limited as all legally taken abalone would be tagged. Tags could also be used as a source of detailed catch data and be linked individually to specific permittees. Additionally, tag fees could help defray management costs.
    - Additional taxes and/or permit fees to support management and enforcement.

Advantages:

- A commercial fishery would be beneficial to the commercial divers and would result in associated economic benefits.
- A recreational fishery would provide resource use to recreational divers and would result in associated economic benefits.
- The state would derive funds from permit fees, and taxes.
- Fishery-dependent data could be obtained and used for management.
- Funding for on-going enhancement projects will continue and a structure will be developed to efficiently direct those funds.
- Monitoring data will direct changes in management and enhancement efforts.
- The presence of commercial divers on the fishing grounds may enhance enforcement efforts.

Disadvantages:

- This alternative may limit recovery elsewhere by allowing limited harvest during the recovery process.
- Reducing the abalone population by fishing may reduce the reproductive potential.
- This alternative will increase the enforcement burden on the Department and the resulting increased need for enforcement could adversely affect other areas if enforcement resources are not supplemented.
- In order to initiate the assessments necessary to implement the recreational portion of this plan, the Department would need to divert staff and funding from other priorities. Existing State law requires the Department to expend dollars to manage the commercial portion of this plan commensurate with the commercial related income we receive from the fishery.

APPENDIX C: MARINE STEWARDSHIP COUNCIL PRE-ASSESSMENT REPORT

REPORT WILL BE PLACED HERE WHEN AVAILABLE

APPENDIX D: OPTIMAL DESIGN AND MANAGEMENT OF A COMMERCIAL FISHING COOPERATIVE FOR THE SAN MIGUEL ISLAND RED ABALONE FISHERY

From the 2009-2010 Bren School Group Project Description. Group Members: Kristen Bor, Heather Hodges, Ariel Jacobs, Dan Ovando, Josh Uecker. Faculty Sponsor: Christopher Costello

This project will evaluate the viability of a self-funded commercial fishing cooperative for San Miguel Island red abalone, while providing management recommendations to our client, the California Abalone Association, for obtaining optimal environmental and economic benefits.

Problem Statement

Red abalone (Haliotis rufescens) is a sedentary species that is extremely prone to overfishing and has been poorly managed worldwide. In Southern California additional pressure was placed on the resource by disease and pollution. In 1997, a statewide moratorium was placed on the commercial harvest of abalone, due to a severe decline in most stocks. Since the passage of this moratorium, some California abalone populations have displayed evidence of recovery. In particular, surveys and stock assessments have shown the red abalone population at San Miguel Island to be both healthy and stable (California Department of Fish and Game 2005). In response, the California Fish and Game Commission is currently considering opening a small-scale commercial red abalone fishery at San Miguel Island. Subsequently, this has created a debate as to how the fishery should be managed once it is opened.

Our client, the California Abalone Association (CAA), a group of former commercial abalone fishermen, has been a key player in the development of a management plan for the proposed fishery. In anticipation of the opening of this red abalone fishery, the CAA has developed a design for a member owned shared management fishing cooperative. The CAA also intends to utilize a catch-share approach in the design of their proposed fishery, by creating a cooperative in which the catch and profits of the fishery, as well as responsibility for funding research and management, are distributed between the members. Recent studies have demonstrated the potential benefits of catch share fishery management systems (Costello et al. 2008, Deacon et al. 2008). Under catch share systems, fishermen are allocated specific rights to the fishery in question, creating an incentive for sustainable management and alleviating the “race to fish” symptomatic of open access fisheries (Costello et al. 2008). The CAA intends to self-fund research and management of the fishery. The CAA has investigated several cooperative designs and needs guidance as to which is the optimal cooperative model if a sustainable abalone fishery is to be opened.

The CAA requires assistance in assessing the economic and environmental viability of the proposed fishery. Many different management strategies are possible for the cooperative, depending on the Total Allowable Catch (TAC), catch share allocation and structure, number of participants, length and timing of the season, costs of operation and management, and state of the abalone resource. Customization of the design is key to the success of a fishing cooperative. As such, the strategy selected must be in line with the specific objectives and characteristics of the proposed abalone fishery; to maximize profits while ensuring the long-term sustainability of the abalone population at San Miguel Island (Costello 2009).

Project Significance

Abalone is an important economic and cultural resource to the State of California. A properly designed and implemented commercial cooperative fishery would:

1. Support local fishermen, restaurant owners, and the local food movement
2. Provide an example to fishery managers worldwide in the design and implementation of a catch-share and community based management strategies
3. Demonstrate the potential for member owned and managed fishing cooperatives to be both sustainable and profitable, and in doing so help shape future fishery policies.

Project Objectives

1. Utilize environmental and economic data to perform a cost-benefit analysis of the CAA's cooperative management structure, in order to evaluate the long-term financial viability of the proposed fishery.
2. Determine alternative management structures for the cooperative, developed from discussions with the CAA and recommendations drawn from collected case studies of similar fishing cooperatives across the globe.
3. Conduct cost-benefit analyses of these alternative plans, and synthesize economic viability reports in order to provide the CAA with concrete data on the economic performance of available management options.
4. Evaluate the economic viability of available management options, under potential environmental and economic states.

Deliverables

1. Develop a comprehensive report assessing the economic viability of a self-funded SMI commercial red abalone fishing cooperative along with providing recommendations for optimizing profits while ensuring the sustainability of the resource.

2. Develop a bio-economic cost-benefit analysis of the CAA's proposed fishery, usable by the cooperative to evaluate the economic impacts of available management options.
3. Present findings to the CAA, which they may then utilize in the formation and implementation of a cooperative that best promises economic viability and environmental sustainability.

Works Cited

California Fish and Game Commission. Abalone Recovery and Management Plan. (2005). http://www.dfg.ca.gov/marine/armp/pdfs/entire_armp.pdf

Costello, C. (Lecture 1/9/2009). Bren School of Environmental Science and Management

Costello, C., Gaines, S.D., Lynham, J. (2008). "Can catch shares prevent fisheries collapse?" Science. 321(5896): 1678 – 1681.

Deacon, R.T., Parker, D.P., Costello, C. (2008). "Improving Efficiency by Assigning Harvest Rights to Fishery Cooperatives: Evidence from the Chignik Salmon Co-op." Arizona Law Review. 50(479): 479-509.

APPENDIX E: SUGGESTED REGULATIONS

It is anticipated that CDFG will develop regulatory language when the fishery is reopened. The cooperative would like to work jointly with CDFG to develop that regulatory language. This appendix contains suggested regulations based on:

- Commercial Fishing Provisions 95-01 for Abalone Diving (as of January 1, 1995)
- Excerpts from Fish and Game Code
- Excerpts from California Code of Regulations (Title 14)

3. Fishermen proposed regulatory modifications regarding the cooperative

1. Commercial Abalone Permit / Title 14. Abalone

Every person who takes, assists in taking, possesses or transports abalone while on any boat, barge or vessel, or who uses, operates, or assists in using or operating any boat or equipment to take abalone must have obtained a valid abalone permit and must be in possession of said permit while engaged in such activities.

2. Diver Participation

Divers "participating" in the fishery will be required to:

a) Purchase/renew their commercial abalone diver permit within the timeframe and guidelines set forth by the California Department of Fish & Game (department)
b) Possess a valid commercial fishing license issued by the California Department of Fish & Game
c) Comply with all requirements set forth by the department
d) Become a member of the cooperative

CDFG Code 5522. (e) states "If the Commission determines that commercial fishing is an appropriate management measure, priority for participation in the fishery shall be given to those persons who held a commercial abalone permit during the 1996/97 permit year."

Cooperative Operating Standard: At the time of the fishery closure in 1997 there were approximately one hundred licensed commercial divers (prior permittees) that could potentially participate in the designated access fishery. The Total Allowable Market Catch (TAMC) will be issued to the cooperative and then divided equally among the "participating" pool of cooperative divers with valid permits.

(1.) Classes of Permits / Abalone Diving Permits

Any applicant who qualifies as a prior permittee in the 1996/97 permit year can apply to the department for an abalone diving permit. The number of permits available to new entrants, shall be the difference between the number of permits issued to individuals qualifying as prior permittees and 35, if the number of prior permittees is less than 35. Abalone diving permits shall be issued in two categories, as follows:

(a.) Prior Permittees

Eligible applicants shall consist of abalone diving permittees who possessed a valid abalone diving permit in the 1996/97 permit year. No abalone diving permit authorized pursuant to this subsection shall be issued by the department following June 30 of each license year. Any person denied an abalone diving permit pursuant to these regulations may request a hearing before the commission to show cause why his request for such permit should not be denied.

3. Permit Year/Season

ARMP Table 2.2 states that the spawning season for Southern California red abalone is year round. For the purposes of this section the abalone permit year shall be from April 1 to March 31 of the following year. If it is necessary to designate a season the cooperative will work in conjunction with CDFG to select a season based on:

a) Biology
b) Enforcement requirements
c) Market conditions

The department shall permanently revoke the commercial fishing license and any commercial fishing permits of any person convicted of a season violation. That person shall not, thereafter, be eligible for any license or permit to take or possess fish for sport or commercial purposes.

4. Limitations and Conditions of Permits

The provisions of the Fish and Game Code and this section relating to abalone shall be a condition of abalone diving permits. An abalone diving permit shall not be assigned or transferred without prior approval by the department, and any right or privilege granted there under may be revoked or cancelled without notice by the commission upon violation of any regulation pertaining to the take of abalone; or violation of any of the terms and conditions of the permit by the holders thereof, their agents, servants, employees, or those acting under their direction and control. A person whose abalone permits has been revoked by the Commission, or who has violated the laws or regulations pertaining to the take of abalone may be required to appear before the commission when applying for other fishing permit.

5. Gear, Equipment, and Method of Take

Every abalone diving permittee shall carry an accurate measuring device and shall measure all abalone before detaching the abalone from its place of attachment. If any abalone under the minimum size is detached by a permittee, he or she shall immediately replace the abalone at its place of attachment. No abalone diving permittee shall throw, cast or drop any abalone into the ocean.

A diver shall be equipped with and use underwater diving gear which shall consist of above-surface air pump operated from a boat and at least 100 feet of air hose, and must be fully submerged while taking abalone.

Abalone may be taken only by hand or with abalone irons. For the purpose of this section, an abalone iron is defined as a flat device not more than 24 inches in length and not less than three-fourths inch wide and not less than one sixteenth inch thick; all edges of the device shall be rounded and smooth. The device may be curved but the radius of the curve shall not be less than eighteen inches.

6. Vessel Identifications

The permit number of the boat operator shall be displayed in 10" high by 2" wide black Roman alphabet letters and Arabic numerals. Figures shall be black on a white background on both sides of the vessel. Numbers shall be displayed at all tunes while operating under an abalone permit. All permittees aboard the boat shall be mutually responsible for the proper display of the numbers.

7. Possession

No person aboard any boat engaged in taking abalone shall take or possess sea urchins on any day or on any fishing trip when abalone have been taken.

8. Black Abalone

Black abalone may not be taken or possessed at any time for commercial purposes.

9. Commercial Permit / §8300.1. Permit Fees; Abalone Diving Permit

Abalone shall not be taken for commercial purposes except under a revocable abalone diving permit issued by the department under regulations adopted by the commission. The diving permit fee is three hundred thirty three dollars ($330).

10. 88301. Unlawful to Remove Abalone from Shell; Penalty.

It is unlawful to remove abalone from the shell or to possess abalones which have been removed from the shell.

The court shall order the department to permanently revoke, and the department shall permanently revoke, the commercial fishing license and any commercial fishing permits of any person convicted of a violation if the court finds that the person possessed more than 24 abalone removed from the shell at the time of the offense. That person shall not, thereafter, be eligible for any license or permit to take or possess fish for sport or commercial purposes.

11. §8302. Food purpose taking only.

Abalone may be taken only for food purposes.

12. §8303. Diving Requirements While Taking.

Only diving apparatus authorized by the commission may be used to take abalone for commercial purposes. Abalone may be taken only when the permittee is submerged.

13. Minimum Size Limit / §8304. Minimum diameter of shell.

It is unlawful to take, possess, sell, or purchase any red abalone, the shell of which, measured in greatest diameter, and is less than 8 inches. Cooperative harvesters intend to select animals above the new 8 inch shell diameter.

The court shall order the department to permanently revoke, and the department shall permanently revoke, the commercial fishing license and any commercial fishing permits of any person convicted of a violation. If the court finds that the person possessed more than 24 undersized abalone at the time of the offense. That person shall not, thereafter, be eligible for any license or permit to take or possess fish for sport or commercial purposes.

14. §8305.9. Authority to open; areas for commercial taking.

The commission may, whenever necessary to prevent overuse, rehabilitate the resource, or otherwise carry out the provisions of this article, close or open areas for up to two years for the commercial taking of abalone, provided that the area opened is also opened or the area closed is also closed to sport taking of abalone.

15. Area.

The area for the initial designated access red abalone fishery will be San Miguel Island (SMI) excluding designated Marine Protected Areas (MPA).

16. Landing Port.

All abalone harvested at SMI by the market sector will be landed at the Santa Barbara Harbor.

17. §8305.10. Opening and Closing Designated Areas.

If the commission opens or closes a designated area pursuant to Section 8305.9, the commission shall not open or close any other area to mitigate or offset the opening or closing of the designated area.

18. Transferring Commercial Permit / §8307. Transferring Permit.

An abalone diving permit may be voluntarily transferred by the permittee, if the permittee has no charges pending for a punishable violation, under either of the following conditions:

a) The permittee held an abalone diving permit in the 1996/97 permit year.
b) The permittee has had a permanent injury or illness that prevents the permittee from commercial diving, and that fact is evidenced by a written finding by a licensed physician and surgeon.

Until the total number of abalone diving permits is 35 or less, a permit may only be transferred if a second, third, or fourth permit (whichever option is selected) is surrendered to the department for cancellation at the same time the application for the transfer is submitted to the department.

An abalone diving permit may be transferred pursuant to this section to a person only if that person meets all of the following qualifications:

a) The person, at that time, holds a commercial fishing license.
b) The person has held an abalone diving permit and the person has not had any commercial fishing license or permit suspended or revoked, has never been convicted and no charges are pending for a violation of any provision of Fish and Game Code or of Title 14 of the California Code of Regulations pertaining to abalone regarding seasons, area closures, size limits, bag limits, possession of shucked abalone, or buying or selling any fish illegally taken in California waters.

c) The person submits to the department's headquarters a notarized letter from each of the permittees described above, each of which includes a statement identifying the person to whom the abalone permit is to be transferred and setting forth the conditions of the transfer, and any necessary documentation that the department may reasonably require to prove that the permittee is eligible to transfer the permit.

The application for the transfer of an abalone diving permit shall be submitted by the person to whom the permit is to be transferred to the department together with the proof that the department may reasonably require to establish the qualifications of that person. The applicant for the transferred permit shall include with the application a transfer processing fee of two hundred fifty dollars ($250). The department may increase the transfer processing fee as required to pay the costs of conducting any additional search of the records for violations committed by the parties.

Upon determining that the transferee of the abalone diving permit under this section is qualified, the department shall issue an abalone diving permit to the transferee which is valid for the remainder of the then current season. An abalone permit issued pursuant to this subdivision shall be renewed in the next succeeding season notwithstanding the any landing requirements.

After the transfer of a person's abalone diving permit, that former permit holder may not take, possess, transfer, or control any abalone for commercial purposes unless otherwise permitted by law.

19.§8307.2. Transfer of Permit in Estate of Deceased Permittee.

An abalone diving permit shall be transferred to the estate of a permittee who has died only for the purpose of transferring the abalone diving permit to another person if both of the following conditions are satisfied:

a) The deceased permittee had no charges pending for a punishable violation punishable at the time of the permittee's death.
b) The deceased permittee held an abalone diving permit in each of the preceding three years.

The abalone diving permit in the estate of a deceased permittee may be transferred to any person who meets all of the following qualifications:

a) The person, at that time, holds a commercial fishing license.
b) The person has not had any California commercial fishing license or permit suspended or revoked, has never been convicted, and no charges are pending, for a violation of any provision of Fish and Game Code or of Title 14 of the California Code of Regulations pertaining to abalone regarding

seasons, area closures, size limits, bag limits, possession of shucked abalone, or buying or selling any fish illegally taken in California waters.

The application for the transfer of an abalone diving permit under this subdivision shall be submitted within one year of the permit holder's death to the department's headquarters by the administrator of the estate of the deceased permittee, identifying the person to whom the permit is to be transferred and setting forth the conditions of the transfer, together with the proof that the department may reasonably require to establish the validity of the transfer request. The application for permit transfer shall be accompanied by a transfer processing fee of two hundred fifty dollars ($250).

Upon determining that the transferee of the abalone diving permit is qualified, the department shall issue an abalone diving to the transferee that is valid for the remainder of the then current season. An abalone permit issued shall be renewed by the department in the next succeeding season notwithstanding any landing requirements.

After the transfer of the deceased person's abalone diving permit, the estate of the deceased permit holder may not possess, transport, or control any abalone for commercial purposes unless otherwise permitted by law.

20.§8309. Sunset/Sunrise Restrictions.

It is unlawful for the holder of a permit to commercially take abalone from one-half hour after sunset to one-half hour before sunrise.

21.§8310. Unlawful Purchase.

It is unlawful for any person to purchase, receive, possess, or sell any abalone, or pans thereof, which were taken illegally in California waters.

22.Revoked or Confiscated Permits

Any revoked or confiscated permit will be eliminated from the overall number of permits and cannot be reissued by the department, until the total number of abalone diving permits is 35 or less. The former permittees catch share will revert back into the TAMC held by the cooperative and be divided evenly among all the identified “participating” divers.

23.Tags

The cooperative will coordinate with CDFG regarding certification and distribution of the tags. These tags will be fixed to each abalone upon harvest. Each tag will identify the permit holder, be sequentially numbered, tamper proof, and use a bar code system. The tag will remain on the abalone all the way to its final destination (i.e., restaurant, etc.) to identify legally harvested abalone in the marketplace. Tags are only valid in the season they are issued for.

24. Landing Receipt

Abalones possessed above the high-water line are considered landed and shall have a valid landing receipt as per Fish and Game Code 8043. Wholesale buyers/fish receivers shall reference the landing receipt on sale invoices and keep appropriate records as per Fish and Game Code 8050 and according to cooperative abalone tracking procedures. The Market Catch Tag numbers will be included on Landing Receipts and transfer tickets.

APPENDIX F: EVALUATION OF THE RED ABALONE STOCK ASSESSMENT BY THE REVIEW COMMITTEE IN SUPPORT OF DELIBERATIONS OF THE ABALONE ADVISORY GROUP

I. Introduction

Review Committee: Schoeter, Butterworth, Gorfine, and Weber

The Review Committee (Doug Butterworth, University of Cape Town; Harry Gorfine, Victorian Department of Primary Industries and University of Melbourne; Stephen Schroeter, University of California, Santa Barbara; Ed Weber, NOAA Fisheries) considered the report from the Technical Panel and associated documents, aided by an interactive discussion with the Panel and other stakeholders. Although data for a stock assessment of the abalone at San Miguel Island (SMI) are limited, the Committee considers that it is not necessary to wait for further data collection before a change in the current moratorium at SMI might be elected. There would be value in a parallel process where some removal was permitted on an experimental basis to provide additional information to that already being collected. Such a level of experimental take must be set conservatively, must be subject to monitoring, and should be reviewed immediately if monitoring indicates adverse trends in abundance that are likely linked to removals.

Here the Committee reviews the input data used in the assessment (Section II), the statistical catch-at-age assessment model (Section III), and risk considerations and computations (Section IV). It then proceeds to comment on experimental removal as a possible way forward (Section V), and on-going resource monitoring that would be necessary to accompany such a program (Section VI). Section VII summarizes the next steps recommended if the proposed approach is to be implemented. This document meets the objectives of the revised Terms of Reference (TOR) for the Review Committee.

II. Data

1. The recent surveys are very good and provide important data that are not normally available to managers. The Committee agrees with the Technical Panel that these are the best data available.

2. Data collection protocols for these surveys should nevertheless be reexamined and altered appropriately to better estimate absolute abundance and proportion of suitable habitat (i.e. non-sand). This can be done by positioning transects along predetermined, randomly chosen azimuth to avoid possible bias. Transect directions should not be altered to avoid sand.

3. It may be possible to include zeros for the areas that were avoided as nonhabitat, and thus calculate a more accurate estimate of abundance in the kelp area for existing surveys. In the future, it may be better to estimate densities and totals based on the survey design (almost a two-stage stratified design in 2006–2008) instead of using geostatistics.

4. The data collected in 2006–2008 should be evaluated to see if it is possible to develop a stratification scheme that would permit similar power with fewer transects. This might involve analysis of hierarchical structure of data to determine appropriate scales of stratification. It is also important to check that stratification actually succeeds in reducing variance. Numbers of samples should also be allocated among strata optimally (e.g., Neyman allocation) based on variance estimates from the existing surveys. Cochran (1977) and Thompson (2002) describe appropriate sampling designs, allocation of effort, and sampling estimators.

5. Use data from existing surveys to determine appropriate sample size and estimate power to detect biologically important effect sizes for comparisons among years. Future surveys must have sufficient statistical power (i.e., precision of effect-size estimates) to detect biologically important changes in abundance of abalone.

6. The assessment of relative strengths and weaknesses of the other survey data by the Technical Panel were accepted given the absence of full documentation. The Channel Island National Park Kelp Forest Survey may not adequately represent the general trends in population vital rates at SMI. It reflects a small area only, and the low densities relative to other areas may indicate marginal habitat.

7. Growth rates of larger, older red abalone reported in the Haaker *et al.* (1998) manuscript are likely to have been biased because the study area was fished, and the relation for larger animals was largely extrapolated. This probably leads to underestimates of $L\infty$ and growth rates, perpetuated through the per-recruit and other analyses for larger red abalone. The Committee notes that this problem is being addressed through additional data collection (Section 6, Bullet 5).

III. Assessment (statistical catch-at-age model approach)

1. The record should be checked for reasons (regulations perhaps) to explain the trend up and then down of the historic catch during the 1990s immediately before the closure of the abalone fisheries.

2. A flexible functional form should be used to model selectivity-at-length for abalone sampled in the 2006+ surveys, and used in providing model predicted values for proportions at length and abundance corresponding to these surveys.

3. The report tabled did not fully explain some of the details of the assessment model, perhaps because it had to be prepared in a very short time; future reports need to provide the specifications of this model in complete detail. Furthermore, such reports should contain summaries that present their conclusions in a form more readily understood by non-specialists.

4. A baseline assessment should be considered based on input from the most reliable data only – likely past catches and the proportions-at-length and abundance estimates from the 2006+ surveys. The effects of adding further relative abundance information should be explored through sensitivity tests.

5. More model fit diagnostics should be reported so that the quality of fits can be judged better, and with a view to clarifying which elements of the inputs have the greatest influence on key features of the outputs (such as recent resource trends): for example, both data and model predictions should be compared for each data series input, together with the value of the associated residual standard deviation, for maximum penalized likelihood estimation.

6. Use of a multinomial with the actual number of animals sampled each year for the likelihood for proportions-at-length likely over weights these data because of their lack of independence. Use of a lower effective sample size, and its effects on results, should be investigated.

7. Consideration should be given to augmenting estimates of more recent year-class strength by shrinkage (Darby and Flatman 1994; Shepherd 1997) to the mean of past values to improve precision (this being a special case of fitting a stock recruitment relationship within the statistical catch-at-age assessment).

IV. Risk considerations and computations

1. Risk should be evaluated in relation to the statistical catch-at-age assessment by projecting the population trajectory estimated into the future, probably for 20 years so that the differing consequences of different options are more readily evident.

2. For the immediate future, risk should be evaluated by projecting forward under different fixed catch levels. At a later stage this should be extended to consider the impact of catches set under some feedback control rules.

3. Future year-class strength in projections should be determined by sampling from a lognormal distribution with mean, variance and first-order autocorrelation determined from the previous 20 years of estimates from the assessment.

Appropriate choices for the values for these parameters might be informed by considering such values evaluated for similar resources elsewhere.

4. Performance statistics reported should include median and 90% probability intervals for the spawning stock abundance, and where relevant for the cumulative catch made.

5. The values for some conventional fishing mortality based reference points (e.g. F40%, as is applied in the case of groundfish) can be established within this framework by projecting the assessment model forward under a fixed catch or fishing mortality until the age-structure stabilizes. The effect of changing the age at first capture should be investigated within this framework, giving consideration also to the population density and hence ease of capture of abalone above the associated minimum size limit.

6. The adequacy of the Abalone Recovery Management Plan (California Department of Fish and Game 2005) generic minimum-viable-population threshold value of 2,000 abalone per hectare for SMI should be evaluated in the context of 20 years of apparent population stability.

7. Application of this value would effectively preclude the re-opening an abalone fishery at SMI at present. However, initiation of an experimental fishery that is (for example) restricted to the Southwest Zone and takes only 5–10 % of the population above 203 mm is a risk-averse alternative, and likely to be well within the level the resource could sustain.

8. The current estimate of an average density of 1,200 red abalone per hectare at SMI is effectively similar to densities for commercially viable abalone populations in other countries once the relative size of, or space occupied by, red abalone is taken into account. A modeling study by Hobday & Tegner (2002) showed that adult (≥ 90 mm) red abalone densities at San Miguel could be expected to be 860 per hectare under a stable catch regime equating to 30% of harvestable size.

V. A Way Forward?

Although the following section extends beyond the Review Committee's terms of reference to some extent, discussions with conveners and stakeholders suggested that there would be value in providing broad indications of a possible way forward for management of SMI abalone based upon review of the analysis presented. What follows should be read understanding that it refers only to initial steps in what would be an adaptive approach, and that subsequent sections enlarge upon associated monitoring requirements and other prerequisites.

1. A program of experimental fishing should be considered for the Southwest Zone as an initial step in pursuing the option for removals. If specific sustainability

criteria are met then this might subsequently be expanded in a stepwise post moratorium process that is consistent with the Abalone Recovery and Management Plan (California Department of Fish and Game 2005). An increased minimum legal size would provide additional resource protection without unduly reducing the available stock. For instance, if set to 203mm as tabled in the 2007 SMI survey report, the stock size would be 9–15% less than at the current minimum legal size of 197mm. A conservative risk-averse approach could be based on the 95% lower confidence level of estimated abundance from the 2007 abundance survey. For instance, an experimental TAC of 8,300 red abalone would provide a viable harvest whilst leaving 90% of the available stock (to which recruitment would be added the next year). Given such a relatively high age at first capture, this 10% proportional take is well below standard fishing mortality reference points.

2. The experimental harvest could be timed to occur during a defined period, allowing for weather and market considerations. This would ensure that concerns regarding regulatory compliance could be more readily satisfied without undue cost.

3. The Southeast Zone should remain as an unfished control region that enables the detection of changes in abundance caused by environmental effects. This region could also be used as a source for brood-stock transplantation as per the option for a non-consumptive TAC.

4. If an experimental commercial harvest is implemented, then recreational stakeholders should be provided with equitable resource access without compromising the integrity of the experimental strategy.

VI. On-going resource monitoring

1. Commercial access to experimental harvesting in any area of SMI should be conditional upon acquisition and provision of adequately precise, spatially resolved, fishery dependent data, and on-going commercial diver participation in fishery independent abundance surveys.

2. Recreational access to experimental harvesting should be conditional upon provision of logbook catch data.

3. On-going fishery independent abundance surveys should occur in all three nonprotected zones of SMI via adherence to a defined sampling protocol. This protocol would be affordable in the medium to longer term with surveys conducted at an intensity and frequency that will enable detection of change at an agreed probability and effect size.

4. The design of recent surveys should be evaluated to seek a less intensive approach without an undue sacrifice of estimation precision. The option of less

intensive but annual surveys is preferred over more intensive but less frequent surveys. Estimation of a trend in abundance from these surveys is important, but will likely require at least 5 years of data before reliable inferences become possible.

5. A tag release-recapture program has been initiated to collect data to support estimation of biological parameters for growth and natural mortality, and is welcomed.

6. Periodic sampling should be implemented to estimate changes in reproductive capacity.

7. The length-frequency distribution of the current stock contains enough large animals to better estimate growth and fecundity in the size range that is actually fished (> ~200mm). The current growth and fecundity models are largely extrapolations of functions that were fit using smaller animals. Some additional growth and fecundity data should be collected with an emphasis on larger animals. The study need not be as extensive as that reported by Haaker *et al.*(1998), which was used in the current assessment.

VII. Next Steps

If the approach outlined above for a possible way forward is taken further, there are certain prerequisites to implementation and permitting removal of abalone.

1. The details of a monitoring program must be specified and agreed to.

2. A power analysis must be conducted to confirm that the monitoring will be able to detect effects of importance, in particular that of reduction in abundance as a result of removals.

3. The statistical catch-at-age assessment methodology should be advanced in line with the advice given above, and used in projection mode to estimate the range of possible consequences for SMI abalone abundance of any level of removals that comes under consideration.

References

California Department of Fish and Game. (2005). Abalone recovery and management plan. Final report dated 9 December 2005. http://www.dfg.ca.gov/marine/armp/index.asp, accessed 24 February 2009.

Cochran, W. G. (1977). Sampling techniques. Third edition. John Wiley and Sons, New York, New York.

Darby, C. D., and S. Flatman. (1994). Virtual population analysis: Version 3.1 (Windows/DOS) User Guide. MAFF Directorate of Fisheries Research IT Report 1. 85 pp.

Haaker, P. L., Parker, D.O., Barsky, K.C., and Chun, C.S.Y. (1998). Growth of red abalone, *Haliotis rufescens* (Swainson), at Johnsons Lee, Santa Rosa Island, California. Journal of Shellfish Research. 17:747–753.

Hobday, A. J. and Tegner, M.J. (2002). The warm and the cold: influence of temperature and fishing on local population dynamics of red abalone. California Cooperative Oceanic Fisheries Investigations Reports 43:74–96.

Shepherd, J. G. (1997). Predictions of year-class strength by calibration regression of multiple recruit index series. ICES Journal of Marine Science, 54: 741–752.

Thompson, S. K. (2002). Sampling. Second Edition. John Wiley and Sons, New York, New York.

APPENDIX G: A NEW BEGINNING FOR ABALONE MANAGEMENT IN CALIFORNIA: CRITIQUE AND COMMENT ON THE ABALONE ADVISORY GROUP'S DISCUSSIONS

By Jeremy Prince and Sarah Valencia – October 2009

I. Executive Summary

Under the Abalone Recovery and Management Plan (ARMP) the San Miguel Island Abalone Advisory Group (AAG) was charged with providing recommendations to the California Department of Fish and Game (CDFG) and the California Fish and Game Commission (Commission) regarding the following areas:

- A Total Allowable Catch (TAC) for San Miguel Island red abalone
- Alternatives for allocation between recreational and commercial take
- Alternative regulations to achieve the TAC and allocation
- Potential management, enforcement, and monitoring techniques

Unfortunately it appears that the AAG has become sidetracked by a discussion of ill-defined risks rather than finding ways to address or mitigate these risks. In the Review Committee it convened to aid this process, the AAG had at its disposal a group of scientists with a wealth of expertise in international abalone and fisheries research, assessment and management, and yet the recommendations made by this body (Butterworth et al. 2009) have been largely left out of the discussions of the AAG as it prepares to make recommendations to the Commission.

This paper seeks to provide CDFG and the Commission with options to consider by building on the way forward recommended by Butterworth et al. (2009). It begins by defining and describing the risks associated with a limited trial fishery at SMI and reviews the science underpinning the core issues discussed by the AAG, as well as the scale at which they must be managed. The suggestions made by Butterworth et al. (2009) are then re-tabled and more fully fleshed out in order to illustrate how such suggestions could be put into practice in the California context.
The AAG's discussions have focused on the following risks:

- Withering foot syndrome disease events
- Predation due to otter encroachment
- Uncertain productivity levels
- Reduced recruitment via the Allee effect
- Uncertain assessments and surveys

The first three of these are actual risks. The first two apply across the entire range of California abalone and must be managed at that scale. However, only the additional risk posed by a trial fishery at SMI is relevant for consideration here. This additional risk, along with that posed by uncertain productivity levels, can be managed with the conservative, modern, internationally recognized fisheries management techniques proposed by Butterworth et al. (2009) and elaborated on below. When we examine the science behind the final two risks (as we do below) it becomes clear that much of the perceived risk is the result of some fairly pervasive misconceptions and misunderstandings.

A. The Allee Effect

The dominant Californian conception of the impact of the Allee effect on abalone is counter to the available abalone science. It is illogical on evolutionary grounds. After all, how can a species ever build up into self-sustaining populations or persist across geological time scales if it has no ability to recover from low stock abundances? A large body of abalone science shows that all species can be highly mobile at scales of 1-100s of meters, and over days, weeks and months. Besides seeking food if necessary, they actively aggregate to spawn, presumably to circumvent the Allee effect. Consequently the Allee effect is only relevant to the consideration of managers if heavy harvesting is permitted immediately prior to or through the spawning season. The disruption of spawning aggregations in the weeks prior and during spawning seasons must be taken into account for management purposes, as it may well prevent the formation of aggregations necessary to achieve the optimal mixing densities of eggs and sperm. Shepherd and Partington (1995), one of the main sources for the Allee concept in abalone, showed that the Allee effect results in a classic Ricker-shaped stock recruitment curve, which relates adult biomass to subsequent recruitment and is commonly incorporated in stock assessments for a wide range of species. The relationship they described between adult biomass and future recruitment for the Australian greenlip became less productive in absolute terms at low abundance so recruitment declined quickly when adult biomass became very low, but nevertheless, it remained productive even at very low abundances.

Analysis of the data collected during the CCDFG and National Park Service (NPS) surveys and presented here show that the biology of abalone revealed in the international literature is also at play in the SMI red abalone population. The population at SMI has grown at 9-10% per annum compounding since the Moratorium on fishing was put in place in 1987. The analyses demonstrate that the concept of Minimum Viable Population (MVP) as cited by the ARMP (2,000 abalone/ha) and applied by the AAG to SMI is a gratuitous extrapolation of its original context and thus has little meaning for the rebuilding of California's abalone resource.

As applied by the AAG, which has followed the protocols developed for the CDFG surveys, the area of abalone habitat at SMI is defined as the area covered by the kelp canopy (1,048 ha) and the surveyed population abundance is divided by this area to produce estimated densities of 1,100 – 1,800 abalone/ha. These densities are clearly below the level defined in the ARMP, a level implied and assumed by the AAG to be driving a continuing decline in recruitment and adult population even without fishing. But those estimated densities are entirely the result of the assumption that abalone area is the same as the aerially surveyed area of kelp canopy. In fact, of the 4,796 survey segments searched during the 2006 survey 70.3% of the area under the kelp canopy held no abalone, a similar distribution to that derived by Prince et al. (1998) for a range of Australian species. According to substrate data collected during that survey of the 70.3% of the kelp canopy without abalone, 12.0% of segments surveyed were sand and 6.8% were cobble (small rocks that can move in heavy surge), both of which are habitat types abalone are not expected to occupy. The remaining 51.5% were apparently suitable habitat but for reasons known only to abalone no abalone were found.

The absolute level of 2,000/ha has little quantitative basis for the Australian greenlip abalone (*H. laevigata)* with which it was developed, and no quantitative basis at all when applied to red abalone. Red abalone are 2-3 times heavier, and so presumably produce 2-3 times more eggs and sperm and thus should be capable of successful spawning if aggregated less densely. Instead, accepting that 2000/ha provides some arbitrary bench mark of the nearest neighbor distances which will impact fertilization success, the 2006 survey show that only 8% of abalone at SMI occurred at densities <2,000/ha. As with abalone all around the world, the red abalone at SMI aggregate and live at densities well above the theoretical MVP. In fact the average abalone surveyed in 2006 was found to be living at 8,185 abalone/ha and >73% of the abalone sampled live at densities > 3,000 abalone/ha.

Thus, as originally conceived by Shepherd and Partington (1995), the Allee effect is nested within the standard fisheries dynamics assumptions about how adult biomass determines the abundance of future recruitment. Left with sufficient time after fishing or predation abalone reform their aggregation structure. It must be assumed that this behavior is to minimize the potential for the Allee effect occurring and in the Australian greenlip it has been shown that proximity to other adults is a necessary stimulant for breeding. However, within the context of abalone assessment and management the Allee effect will have little consequence, unless heavy fishing is permitted immediately prior to or during the spawning season, when the effect of fishing will disrupt breeding aggregations and prevent the abalone achieving optimal fertilization conditions. Without the physical effect of heaving fishing through the spawning season the Allee effect is incorporated into standard fisheries assumptions about the relationship between adult stocks and future recruitment which are that stocks remain productive, but at lower absolute levels, even when relatively depleted.

B. Uncertain Assessments and Surveys

The outputs of the AAG modeling process, which purport to show that recruitment and biomass at SMI is continuing to decline without a fishery or some other exogenous cause of mortality, are entirely baseless. As illustrated with quotations by a trinity of the world's most experienced fisheries assessment modelers (Hilborn, Walters and Punt) a standard practice in fisheries assessment is the error checking of models by testing whether they decline in the absence of fishing. This basic test has not been performed for the AAG, and in fact this scenario has been accepted as the AAG's base case. As argued above, with regard to the Californian conception of the Allee effect, the notion that a population will continue monotonically declining without some source of external mortality (fishing, heavy predation or disease) is so inherently unlikely from an evolutionary perspective it should never have been accepted by the AAG without strong and compelling evidence that it is in fact the case.

As concluded by Butterworth et al. (2009) this modeled result has most likely been driven by the unfounded assumption that the selectivity of the survey protocol with regard to the cryptic juvenile size classes has remained constant through the many surveys the CDFG have conducted since the 1970s. This is clearly not the case. Prior to the 2006 surveys the protocols included turning boulders and searching the cryptic habitat preferred by the smaller abalone. The most recent survey protocol does not include searching for juveniles in this way. The model assumption of constant survey selectivity will have created the result which makes it appear that recruitment rates have declined over the last decade, which in turn will drive the result that adult biomass is declining.

The reliable data in the situation are:

- the time series of adult size structure from the CDFG surveys
- the recent CDFG survey data since 2006 and
- the National Parks surveys conducted by CINP at Wycoff Ledge at SMI since 1983 using a standard protocol.

All these solid lines of evidence show the population at SMI has been increasing since the moratorium. Based on the Wycoff Ledge data we estimate a compounding rate of 9.5% since the close of the fishery. This is in keeping with the international understanding of abalone fisheries dynamics, while a modeling process that describes decline in the absence of fishing is not.

C. Managing Risk and Uncertainty

Butterworth et al. (2009) suggested that these various sources of risk and uncertainty, real and perceived, should be managed and quantitatively evaluated with a trial fishery in the southwest zone of SMI. To that end they recommended applying a world's best-practice approach with a conservative bias to set up a closely monitored, limited trial fishery in the southwest zone of SMI. The approach they recommended would constrain the harvest to a sub-section of the SMI resource allowing both the impact of fishing and future environmental variability to be determined through future surveying inside and outside the trial fishery. Butterworth et al. (2009) also suggested that areas outside the trial harvest area could become the source for brood-stock transplantation as per the option for a non-consumptive TAC.

Butterworth et al. (2009) recommend that the uncertainty in survey estimates and the productivity of abalone be managed by setting a conservative TAC for the trial fishery based on the 95% lower confidence level of population estimates derived from survey data, and a harvest rate of 10% on the abalone above 8 inches (203 mm). This approach will ensure there is only a 5% chance of the actual population being smaller than the survey estimate, and that the harvest rate is equivalent to the lowest end of estimates of natural mortality of abalone. In the opinion of Butterworth et al. (2009) "[g]iven such a relatively high age at first capture, this 10% proportional take is well below standard fishing mortality reference points."

Pursuant to these suggestions and applying a quantitatively proven approach used in both the South Australian and Victorian abalone fisheries (McGarvey et al. 2008, Mayfield et al. in prep), we employ a bootstrap analysis of the 2008 survey data to populate a decision table which managers can use to balance acceptable and explicit levels of uncertainty and risk with TAC levels for the southwest zone of SMI. Following the recommendations of Butterworth et al. (2009) the 95% lower confidence interval estimate and a 10% harvest rate on abalone larger than 8 inches suggests a TAC of 10,728 abalone.

D. Recommended Process for Managing SMI Abalone

Finally this document outlines a short- to medium-term process by which the trial fishery at SMI should be managed. The proposal for this process has been developed over several years in consultation with the Californian Abalone Association (CAA), CDFG staff and a range of external technical expertise.

The CAA would establish a harvesting cooperative to receive a TAC allocation, which would require annual CDFG approval contingent on adherence to previously agreed upon conditions and standards. Within that context the CDFG and the harvesting cooperative would develop a Memorandum of Understanding (MOU) documenting the standards and conditions required, and this MOU would be presented to the Commission for approval. It is suggested that these standards and conditions would initially involve setting the TAC for the southwest zone of SMI using a Decision Table similar to that presented here (Table 1). So as to minimize any additional risk from disease or otter predation it is proposed that meta-rules would set future TACs to zero in the event of a disease outbreak or encroachment by otters. This would necessitate continuing annual surveys to monitor abundance, aggregation structure and size composition as well as disease status and otter predation. Under the MOU the harvesting cooperative would also plan and coordinate with the CDFG short periods of structured harvesting with the aim of increasing the transparency of the harvest process and creating cost efficiencies in the catch monitoring and enforcement processes. The MOU would also require the harvest cooperative to gather detailed logbook and electronic data recording details of that catch (weight, number and size) and effort (time spent harvesting, GPS tracks of divers).

In the medium- to longer-term a Decision Tree approach should be developed so that spawning biomass targets can be explicitly incorporated into the TAC setting process. To this end the initial TAC should also include provisions to obtain length based samples of red abalone for biological studies so that locally accurate models of Spawning Potential Ratio, (or SPR), also referred to as Full Life-time Egg Production (FLEP), can be developed. This would then allow the local biology of red abalone to be incorporated into the TAC setting process with the aim of explicitly managing to conserve levels of spawning biomass proven by international experience to support continued population growth.

II. Introduction

After the adoption of the Abalone Recovery and Management Plan (ARMP) in December 2005, the Department of Fish and Game (CDFG) moved forward with the consideration of a limited abalone fishery at San Miguel Island (SMI) prior to full recovery. In order to maximize the CDFG's ability to properly design this fishery a cooperative planning approach was created to directly involve stakeholders in development of potential fishery alternatives. Charged with leading this cooperative approach, the San Miguel Island Abalone Advisory Group (AAG) was empanelled to provide recommendations to the CDFG. The AAG was not established as a decision making body; instead it was to provide recommendations to be considered by resource managers of the CDFG and the Fish and Game Commission (Commission). The AAG was not expected to reach consensus, rather it was expected to develop a reasonable range of alternatives that achieve the goals of the ARMP.

The AAG was charged with providing recommendations regarding the following areas:

- A Total Allowable Catch (TAC) for San Miguel Island red abalone
- Alternatives for allocation between recreational and commercial take
- Alternative regulations to achieve the TAC and allocation
- Potential management, enforcement, and monitoring techniques

We have been privileged to attend several AAG meetings in person and by phone and have followed much of the documentation that has been generated by the group. Unfortunately it appears that the AAG has become sidetracked by a discussion of ill-defined risks rather than looking for solutions to address or mitigate these risks. An international panel of experts, invited to review the AAG's assessment of SMI (Butterworth et al. 2009) politely pointed this out and attempted to return the AAG's discussion to its central tasks. However that panel's work also seems to have been lost without comment in the AAG's processes, and the AAG has been bogged down for many months without making progress on providing recommendations for TACs, alternatives for allocation and regulating TACs and potential management, enforcement and monitoring techniques.

This paper seeks to fill in the gaps surrounding the sources of uncertainty that have consumed the AAG's discussions and build on the way forward recommended by Butterworth et al. (2009). We define and describe the perceived risks that the AAG has associated with limited trial fishery at SMI, and review the science underpinning the main issues as well as the scale at which they operate and must be managed. With the aim of giving the CDFG and the Commission options to consider, it re-tables the suggestions of Butterworth et al. (2009) for a way forward and fills in some of the detail that will be required to implement that initiative.

This paper supports the suggestion of Butterworth et al. (2009) for a limited, closely-studied trial fishery within a restricted area on the southwest corner of SMI and illustrates that this is the only method of those currently under consideration that would allow both continued monitoring as well as direct testing of the concerns raised by the AAG process. Finally, in response to the recommendations of Butterworth et al. (2009) this paper provides a detailed integrated risk management framework and outlines a quantitative harvest policy that could be developed further within the framework of the ARMP.

A. Risk Management

To incorporate risk into management one must go beyond the probability of the occurrence of the event and consider the scale, magnitude and longevity of the impact of that event if it were to occur. In this way a rare but manageable event with grave irreversible broad-scale impacts will be managed as a higher risk than one with a significant impact that is common but short term and local (Berkes et al. 2001). Resources such as California's red abalone (*Haliotis rufescens*) stock face a suite of risks across scales extending from individual reefs to the entire species range and spanning weekly to decadal time frames. Appropriate management measures must address these different scales through a range of socio-political devices. The AAG was established by the Commission to develop a range of alternatives for managing a limited fishery for red abalone at SMI. To fulfill this task, the AAG must address the management of the *additional* risks posed to the red abalone population by this proposal and should focus its discussion on managing those local and additional risks rather than the broad scale risks to abalone across the entire state of California.

The focus of this paper will be on this narrower subset of additional local risks posed by the SMI proposals rather than the long term broad-scale risks of disease, predator expansion and climate change, which must necessarily be dealt with by statewide political mechanisms. Despite this focus, the tenor of the AAG's recent discussions makes it necessary to place these limited additional local risks within the broader context of perceived risks.

The main perceived risks that the AAG's discussions seem to have focused on include:

- Withering foot syndrome disease events
- Predation due to otter encroachment
- Reduced recruitment via the Allee effect
- Uncertain productivity levels
- Uncertain assessments and surveys

III. Sources of Risk

A. Withering Foot

The withering foot syndrome (WFS) seems to be less pathological to *H. rufescens* in cooler waters. Being on the oceanographic boundary and receiving abundant cold water influences, the SMI population has apparently remained relatively unimpacted by WFS to date. This situation might be expected to change some time in the future, particularly with global warming. On the other hand it might be hoped that, as time passes since the first exposure, some level of resistance to WFS is also accumulating. Since the strong La Niña event in the early 2000s commercial, recreational and research divers throughout southern California have reported growing numbers of small aggregations of several abalone species in former beds. Recovering populations as far north as the Farallon Islands could be reduced again by a resurgence of WFS which might accompany a period of strong El Niño conditions and warm surface waters unless some level of resistance has been developing over the last three decades.

It should be noted that the status of recovering abalone populations are currently not being monitored outside of the SMI initiative. It should also be noted that the risk of WFS cannot really be managed in any significant sense of the word. Any disease event in southern California cannot be prevented from occurring, or ameliorated once it has occurred. Management can only rebuild and maintain populations at robust levels in a number of locations in the hope of greater survivorship after a disease event. The risk of such an outbreak is independent of whether or not a trial fishery occurs on a part of SMI. The only additional risk in the co-occurrence of a trial fishery and a disease event would be a slightly higher level of depletion in the area of the trial fishery. If the fishery is restricted to a specific area the additional risk will also be localized and can be reduced to almost zero by:

1. Allowing only a light abalone harvest in the fished area so that fished and unfished populations remain at similar high levels in case of disease event.

2. Making the TAC conditional on population monitoring demonstrating that the population remains un-impacted by disease.

3. Ceasing fishing at the onset of a WFS outbreak to prevent further depletion of disease-depleted stocks.

Thus risk from a WFS outbreak can be managed by conducting disease monitoring programs in conjunction with annual surveys and agreeing to a meta-rule that the annual TAC should be set to zero in the event that a disease outbreak is detected, and until the population rebuilds to the previously fished level.

B. Otter Range Expansion

If the range of sea otters expands any further into Southern California the abalone population at SMI is likely to be depleted by >90% and will obviously not be able to sustain a fishery. This issue is similar to the risk posed by WFS: it will not be managed or monitored in southern California outside of SMI, it cannot be effectively prevented, and its impact will be far greater than a light human harvest. The only amelioration possible if it occurs is to avoid adding fishing pressure on top of otter depletion.

Likewise the risk to the SMI abalone populations from future depletion by sea otters is independent of whether or not a trial abalone fishery is attempted before that happens. The only additional risk posed by a trial fishery will be limited to the fished area and that can be avoided by agreeing to incorporate another meta-rule into the harvest strategies decision rules so that the annual TAC is set to zero in the event that sea otters encroach upon abalone grounds at SMI.

C. Allee Effect or Minimum Viable Population (MVP)

1. Broader Academic Context

The Allee effect refers to a reduction in reproductive success at low population numbers. In the case of abalone, gametes released into the water columns are unable to find each other, and this fertilization cannot occur. In the abalone literature the idea originally derives from work done on the Australian greenlip abalone (*H. laevigata*) that demonstrated and modeled the phenomena using the results of laboratory and field studies.

Shepherd and Brown (1993) introduced the terms “Minimum Viable Population” (MVP) and the “Allee effect” into discussions of abalone ecology. They observed trends from 1968 to 1990 in a population of *H. laevigata* living inside and outside of a marine reserve at West Island in South Australia. The study site was a contiguous reef complex over an area of approximately 4,120m^2, of which almost 20% was protected by a small (800m^2) marine reserve. Greenlip abalone populations are known to be highly mobile (Shepherd and Partington 1995) and the majority of the reef area remained fished during the period of the study. A low level of illegal harvest in the marine reserve may also have occurred.

Shepherd and Brown (1993) observed a starting mean density of 3,700 abalone per hectare (ab/ha) in 1970, which had declined by 23% in 1983, and by 68% in 1990. The proportion of aggregated adults in the area open to fishing (Dinora Reef) declined from 68% down to 14% in 1990 as densities declined from 2,120 to 1,070 ab/ha. A shift in size structure also occurred but differed between areas. On Dinora Reef, outside the reserve, the proportion of abalone >130 mm (the legal minimum size) declined from 40% of adults in 1983 to 28% in 1990 whereas within the reserve the same size class increased from 20% to 28% during the same period. Shepherd and Brown concluded that fishing over the majority of the reef and possibly some illegal take from the marine reserve caused the population to decline from around 1,500 mature animals in 1970s, down to <500 in 1990.

Recruitment in the marine reserve, monitored as the number of 2-3 year old abalone emerging, was first observed to be relatively low during the period 1975-79. Although it returned to higher levels for a period, Shepherd and Brown believe that the period of lower recruitment, combined with continued relatively uncontrolled fishing, started an ongoing decline in adult numbers which drove densities down to levels where aggregations were disrupted and Allee's effect became a problem, and as a result recruitment failed after 1984: "It is clear, in retrospect, that a population size of less than about 800 individuals [1,940 ab/ha] was critically low and must have increased the probability of further decline." Shepherd and Brown emphasized the additional impact on reproductive potential due to rarity. Noting that the proportion of the population found in aggregations declined from 76% to 16% while density declined from 1.8 to 0.7/m^2, Shepherd and Brown concluded that "the loss of reproductive potential due to fishing is multiplied by a factor related to the ability of abalone to aggregate. Thus the effective population size declines more rapidly than the true population size as density declines." (p. 2005, Shepherd and Brown 1993).

In parallel to the above study Shepherd and Partington (1995) published a paper on the population dynamics of greenlip abalone in Waterloo Bay and used that as a means to discuss similar issues. The Waterloo Bay stock is a genetically and reproductively isolated stock that Shepherd surveyed from 1978-90. The stock is clearly defined by its isolated geography and through the movement of sub-adults and adults remains relatively homogenous despite occupying several distinct habitat types. Waterloo Bay was fished heavily from the early 1970s until closure to fishing in 1982, and then re-opened to fishing in 1986 with a size limit increase. Shepherd and Partington (1995) found that, while influenced by many factors, recruitment (measured as abundance with a two year lag) was 2.7 times higher in the six years following the closure than in the preceding seven years under intense fishing. Under intense fishing with low size limits aggregations were fewer and smaller. When fishing ceased the size of the abalone and the clusters they formed increased, and they declined again when fishing recommenced, but they noted that during the second period of fishing the size of abalone and their clusters remained larger than when fished initially because the size limit had been increased (Shepherd and Partington 1995).

Shepherd and Partington (1995) used trends in the size of aggregations along with a model developed for sea urchins to relate the intensity of aggregation to fertilization success and adult abundance, and with this model they estimated a stock-recruitment relationship for Waterloo Bay. The shape of the curve they estimated is a classical Ricker type showing a compensation at high stock sizes and indicating that below adult densities of about 1,500 – 2,000 ab/ha the population is increasingly vulnerable to recruitment failure and ultimately to collapse.

> *"[T]he positive intercept of the curve which is analogous to a depensatory effect (Clark 1974) may have biological significance. It may indicate the strength of the Allee effect. This is supported by the present data on density v. proportion clustered showing zero clustering at low densities under heavy fishing. In this respect the WB data are in fair agreement with Shepherd and Brown (1993) in which recruitment failed below a mean density of about 3,000 ab/ha. Subsequent history of the WB population has borne this out because it had again collapsed by 1994 with a return to the low densities of 1976-78." (p. 678, Shepherd and Partington 1995)*

Babcock and Keesing (1999) measured fertilization rates in the laboratory as a function of sperm dilution and also conducted tests in the field to measure the decline in fertilization rate as a function of distance from where the sperm was experimentally released. They observed that fertilization rates declined abruptly with increasing distance from the point of release but concluded that the decline was not as abrupt as that observed with sea urchins and smaller than that measured for starfish. In their discussion they suggest this may be due to the synchrony of abalone spawning and the selection of low water flows for pulses of spawning. Using reported densities from the earlier studies of Shepherd and Brown (1993) and Shepherd and Partington (1995), which have been discussed above, Babcock and Keesing went on to argue that populations with nearest-neighbor estimates for male-female of 1-2 m were prone to declining, while the stable populations they worked with had estimate male - female distances <1m.

2. Allee Effect in California Management

At the time of the fishery closure in 1997, few references had been made to the Allee effect in California. Tegner et al. (1989) was the first to touch on "reduced fertilization efficiency" as one of a number of possible explanations for the observed decline in landings. Later, Tegner et al. (1996) and Davis et al. (1996) drew directly from the Australia literature (McShane 1995, Shepherd and Brown 1993) to describe the phenomenon of depensation as a factor in the decline of white abalone (*H. sorensii*). Interestingly, Tegner et al. (1996) cited a minimum viable population as being “more than 800 individuals” while Davis et al. puts the number at “several thousand individuals”, adequately capturing the general lack of consensus in the literature.

By the early 2000s, however, the Allee effect had come into vogue, with a number of papers citing the phenomenon as a major player in the decline of California’s abalone fishery. The term’s inception in the California context can be traced to the *Workshop on Rebuilding Abalone Stocks in British Columbia,* in which five of the papers presented alluded to the idea (see Tegner 2000, Davis 2000, Jamieson 2000, Campbell 2000, and Withler 2000; Tegner 2000 also cites Babcock and Keesing 1999). Also presenting at this workshop were biologists from the CDFG who would later play a significant role in drafting the state’s ARMP. (see Karpov et al. 2000).

By the time the ARMP was adopted in late 2005 the concept of the Allee effect and a corresponding minimum viable population (MVP) for abalone was firmly entrenched in the lexicon of abalone management in California. This is reflected in the ARMP, which sets the MVP for each of the seven species at 2,000 individuals per hectare (ha) and bases this on two sources. The first is Shepherd and Brown (1993); the second source is Tegner et al. (1989), which describes mean densities at Santa Rosa Island from 1978-82 as being “comparable to the average 0.2 abalone per m^2 found in the Victorian fishery for *H. rubra*” (Tegner et al. 1989). The ARMP interprets these results to illustrate the densities precipitating the decline of the fishery (Karpov et al. 1998); however, the Tegner paper points to an already declining fishery. The ARMP notes that the “MVP for each species may change as more information on recovering populations is obtained.” (p. 75, ARMP).

3. Abalone Ecology

Abalone ecology leaves little doubt that, at extremely low densities, the Allee effect is real. However, in the AAG’s discussions and in the general context of Californian abalone management, the concept has been applied in a manner that is conceptually different from its original application and contrary to the scientific data. Shepherd and Brown (1993) found declines at low density in very small, isolated populations of a few thousand individuals, while at SMI even the most conservative interpretations of the last few years of survey data put the population at a few hundred thousand emergent abalone, and likely much higher. In this flawed application of Allee’s effect red abalone are implicitly regarded as immobile, fixed to their scars and unable to cross the meters that may separate them to aggregate at densities capable of optimizing fertilization. The Technical Panel’s model runs showing a continued decline in recruitment since the moratorium bolster this circular thinking. The implied logic is that, once fishing depleted the population, the abalone left dispersed by fishing never re-aggregated, even after a decade without fishing.

The AAG has attempted to use kelp canopy, quantified with aid of aerial photography, as a proxy for the area of kelp beds, and then arbitrarily defined this as the area of available abalone habitat. As a result, the MVP for SMI as outlined by the ARMP is calculated as:

>2,000 abalone x 1,048 ha (estimated total area of kelp canopy, excluding marine reserves) or 2,096,000 abalone at SMI

But this does not account for the fact that a high proportion of the sea floor that falls under the kelp canopy is sand (abalone prefer rocky reef substrate). It also does not take into account the fact that typical abalone habitat is some sub-set of the total reef area found within the canopy cover of the kelp beds, and that there are areas where abalone are never observed despite the classification of "potential habitat". Typically 70-80% of an abalone stock will be found living at high densities in just 20-30% of the habitat (Prince et al. 1998) and this pattern of aggregation has probably evolved to improve reproductive success. Finally, it does not explain the fact that, by a number of accounts from commercial, recreational, and research divers, abalone sightings have increased in frequency since the moratorium despite the fact that populations have been determined through survey efforts to be below this rather arbitrary magic number.

If this logic is correct, how can abalone populations ever recover from low levels, and how did abalone populations build up in the first place following the depletion of otters in the 1800s? This is a view that assumes they have no natural resilience and can never recover from an event that badly depletes them.

This conception is flawed because abalone have evolved patterns of movement which minimize the potential for Allee's effect occurring, and so confer on the species the resilience they have needed to survive for millions of years. Abalone do not remain immobile, as casual observers of the scar beneath an abalone might be tempted to think. Instead, a broad range of studies show that abalone within populations are extremely mobile, moving in and out of feeding aggregations and aggregating more intensively to breed (Ault and DeMartini 1987, Prince 1989, 1992, Shepherd 1986a and b, Shepherd and Partington 1995).

Ault and DeMartini (1987) released 3,877 tagged red abalone at Point Cabrillo and re-sighted 58% at least once over the next five years. They measured a median distance moved of 87m and a range of movement rates from 1 to 150m per month:

> *"The red abalone population at Point Cabrillo was in a constant state of flux due to movement and dispersal, with the new members entering the area as well as leaving the area. However, some abalone remained in the general vicinity for relatively long periods. We probably have underestimated the extent of movement as it is likely that some abalone left the zone in which they were released, only to have returned to the*

> *same general vicinity before the next observation." (p. 209, Ault and DeMartini 1987)*

They also noted that some abalone were likely to have moved out of the research site. They observed 29 instances of movement >350m over 3 to 61 months between sightings. One tagged abalone released in the Inner Surge Channel of their site was "recovered alive approximately 9 years later by a sport diver near Caspar State Beach, a distance 2.4km north of the study site in least-linear transect from the point of release." (p. 208, Ault and DeMartini 1987). They surmised that food availability influenced movement rates as they had gained the qualitative impression that movement was less and scars were more deeply formed where food was abundant.

Frequent movement has also been documented within populations of Australian greenlip abalone. Shepherd and Partington (p. 678, 1995) noted that within Waterloo Bay "on reefs of low relief, where crevices are often in limited supply, abalone keep moving in the direction of approaching swell until they find a crevice. In this habitat up to 90% of the population may be mobile." Shepherd (1986) documented a seasonal signal in the degree to which greenlip abalone aggregate at the seaward edges along the sand-lines of the reef. A larger proportion of the population was found in aggregations immediately prior to and during the spawning season. More recent research has shown the sand-line habitat to be the favored settlement habitat for larval greenlip (Shepherd and Partington 1995). Shepherd and Partington (1995) and Babcock and Keesing (1999) both emphasize the importance of greenlip abalone physically moving into aggregation as a stimulus for initiating spawning activity.

Prince (1989, 1992) provides a similarly mobile picture for the Australian blacklip abalone (*H. rubra*). During a four-year study some 7,500 abalone were tagged in an isolated 1km^2 reef in southern Tasmania, Australia, which local divers had closed to fishing. A total of 1,219 movements were observed between points of a permanent transect during a multiple-recapture study, and a single-point-of-release-and-recapture study was also conducted during which the movement of a further 2,503 abalone were recorded. Together with mapped abundance and feeding studies, Prince (1989, 1992) used these data to model the movement and distribution patterns of abalone on the reef. Movement was modeled simply as a slight tendency to move to shallower areas to aggregate for breeding countered by an increased probability and rate of movement if food availability was reduced by high abalone densities. These two simple counter-acting movements explained the clustered distribution pattern mapped for the study site.

Observations of *H. midae* recorded by Tarr (1995) support Prince's conclusions regarding the influence of the opposing forces of competition for food and reproductive success on abalone distribution. Tarr followed a small group (n=58) of *H. midae* on two rocks in a marine reserve in South Africa for three years and found that 46.6% of these individuals were still on the rock at the end of this time, with 81.5% of these stationary abalone occupied their original scar for the entire time. According to Tarr, "[t]he mean size of the abalone tagged was large, and all the smaller abalone eventually moved from the site." (p. 586, Tarr et al. 1995) He attributes this sedentary behavior in mature adults to site preference, noting that, "once a favourable site has been occupied, an adult will defend it against other abalone, with violent rotation of the shell, thereby ensuring an even spacing of adults over prime reef areas." (p. 586-7, Tarr et al. 1995). In this way, abalone are able to structure their distribution to achieve their preferred densities. Tarr also notes that movement is a normal part of the ecology *of H. midae*: "[A] gradual offshore movement of abalone must occur as individuals disperse to favorable reef areas, and aggregations of adults develop in these areas." (p. 588, Tarr et al. 1995)

A few papers have examined abalone movement in the context of fisheries management. Officer et al. (2001) studied the propensity for blacklip abalone to re-aggregate after fishing. They surveyed abalone in four (two fished and two control) plots of 576m^2 at two sites before a controlled removal of 35% of the abalone present, three to four weeks after a fish down, and again ten weeks later to assess recovery. Officer et al. observed "a decrease in the abundance of less than 20%" in fished sites, indicating that abalone had indeed moved into the plots from outside areas (p. 773, Officer et al. 2001). Officer et al studied not only movement but aggregative behavior, noting that "[i]n both sites approximately 80% of abalone were located within 30cm of their nearest neighbor" before fishing, and that, by the second post-fishing survey, nearest neighbor distributions had returned to the distribution found prior to fishing. While this tendency to move after fishing can strongly impact estimates of abundance and natural mortality and should be taken into account in managing a fishery, it also illustrates the ability of abalone to re-aggregate to their preferred density in the face of fairly heavy fishing. Dixon et al. (1998) used a similar experimental design and estimated similar abalone dispersal and re-aggregation rates in response to fishing.

The observations of the spawning of *H. kamtschatkana* by Breen and Adkin (1980) and Stekoll and Shirley (1993) reveal an even more highly mobile view of behavior during the act of spawning with abalone climbing to the highest points of the reef, piling on top of each other five to six abalone deep, and climbing together up onto the stipes, stalks and blades of the kelps around them. Abalone eggs are heavy and the climbing behavior during mass spawning is thought to optimize fertilization success by allowing females to drop their eggs down through the cloud of sperm created by males under the conditions of low water movements selected by the abalone for spawning. Similar behavior has been reported by Australian commercial divers who have observed natural mass spawnings of *H. rubra* (Prince personal observation).

As demonstrated in this review, the overwhelming body of science shows that on scales of tens and even hundreds of meters and over time scales of nights, weeks and months abalone are remarkably mobile, and aggregate even more actively during their breeding seasons. It is also known that manufacturing the slime trail over which they glide is an energy intensive process (Culley and Sherman 1985), so the observed aggregative mobility associated with breeding is unlikely to have evolved without strong evolutionary reason. It follows that this evolutionary reason is to improve the resilience of the species by minimizing the potential for Allee's effect occurring. It can be assumed these movement patterns exist so that whatever abundance of abalone exists in an area at the time of spawning, they will form aggregations at densities likely to optimize their fertilization rates.

Accepting this logic, Allee's effect is only likely to occur when fishing continues through the spawning season at rates that deplete aggregations faster than they can reform, as was the situation observed by Shepherd and Brown (1993) and Shepherd and Partington (1995). But the obverse of this logic is that in unfished populations, or where fishing is light and or occurs months or weeks before the spawning season, the Allee effect poses little if any risk.

4. Distributional Analysis of 2006 SMI Survey Data

A simple analysis of the distributional data gathered during the 2006 SMI surveys illustrates the propensity of abalone to form aggregations and live at high densities. The CDFG survey protocol considers the entire area under the kelp canopy of SMI to be abalone habitat and involves counting abalone within 5m segments along transects placed randomly under the kelp canopy. The boundary of the kelp beds, and so by definition the area of the survey, is determined using aerial photographs of kelp canopy. For this analysis the 2006 SMI survey counts of abalone within each 5m segment of the transect are each used as an estimate of the density at which the sampled abalone were living.

Analyzing the data this way shows that, of the 4,796 segments surveyed, 70.3% of the area under the kelp canopy held no abalone. According to substrate data collected during the survey of this 70.3% of the kelp canopy without abalone, 12.0% was sand, and 6.8% was cobble (small rocks that can move in heavy surge), both habitat types abalone are not expected to occupy. However, based on the substrate data the remaining 51.5% was apparently potentially suitable abalone habitat although it did not contain abalone.

Figures 1 and 2 provide two views of the observed density profile formed by SMI abalone within the remaining 30% of the habitat. Figure 1 plots the percent of abalone sampled against the density at which they were observed within each 5m segment of transect. It shows that almost 10% of the sample was recorded at densities of around 2,000 abalone/ha and that only 8% of the sample was found occurring at densities below this level. Figure 2 shows a similar view to figure 1 but plotted as the cumulative percent of the abalone sampled. From figure 2 it can be seen that >73% of the sample occurred at densities of 3,000 abalone/ha or greater and at those densities they cover approximately 10% of the broader survey area. This concentration profile is a common feature of abalone populations with 70-80% of the population normally occurring in 10-20% of the potential area (Prince et al. 1998).

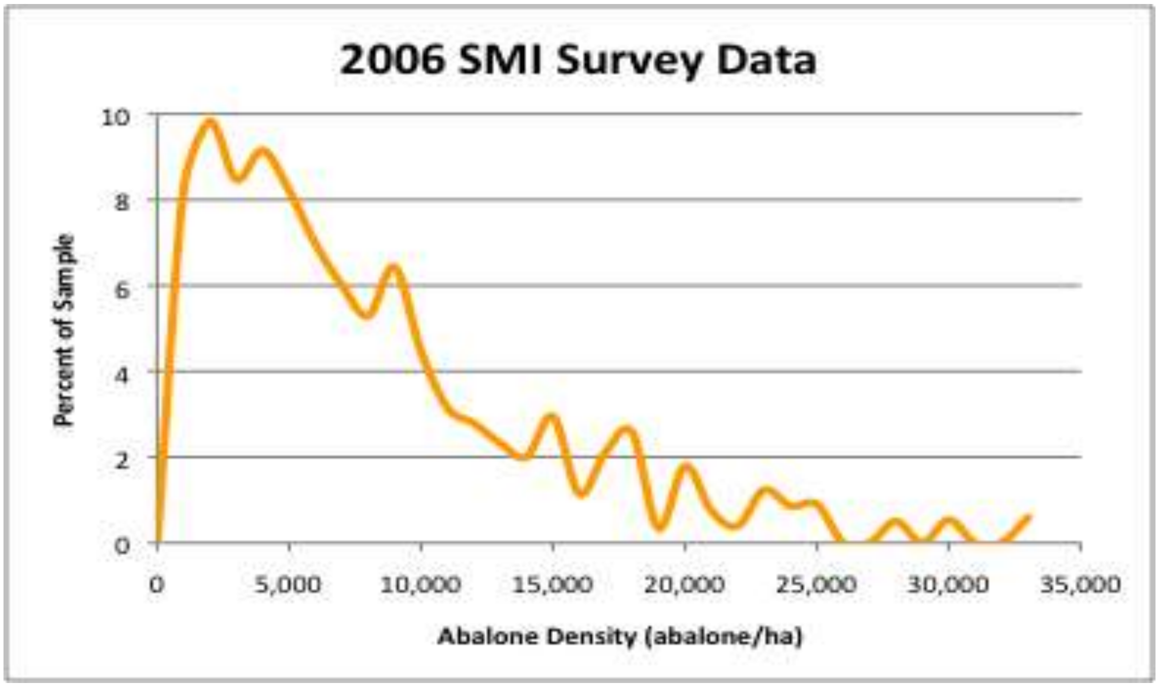


Figure 1. Percent of abalone sampled during the 2006 surveys plotted against the density at which they were observed within each 5m transect segment.

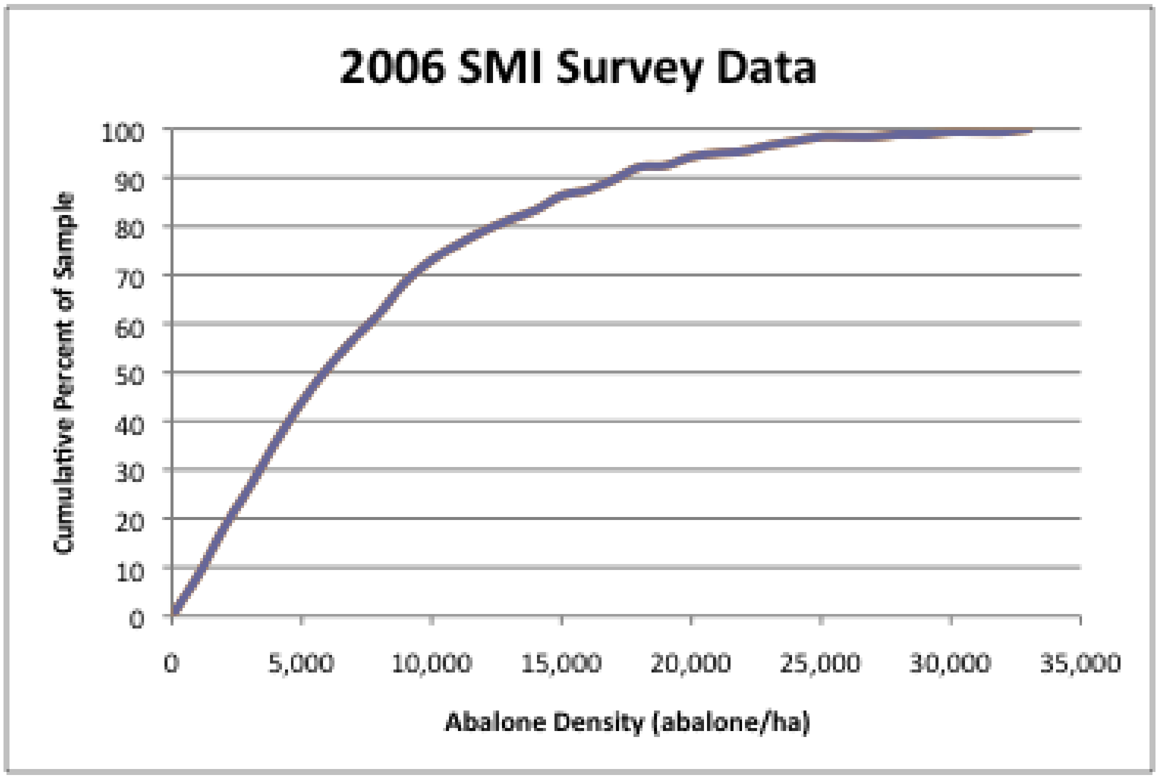


Figure 2. Cumulative percent of abalone sampled during the 2006 surveys plotted against the density at which they were observed within each 5m transect segment.

From these data it can also be estimated that, while abalone were only observed within 30% of the habitat covered by kelp canopy, their average density in the areas they occupied is actually 8,185 abalone/ha, well above the MVP specified in the ARMP. It is at this localized density that fertilization and larval dispersal is occurring. Given the difference between the size of the area deemed by survey protocol to be abalone habitat and the area the abalone have actually selected to aggregate within, it is not surprising that the latest density estimate derived from the survey and used by the AAG (1,539 abalone/ha in 2008) is so much lower than the actual effective density (8,185 abalone/ha) at which the average abalone at SMI is spawning. Clearly the estimated survey density and the AAG's application of the concept of MVP is an anthropomorphic construction which has little relevance to the density at which the average abalone SMI actually experiences. The abalone demonstrate by their actual distribution that the human definition of abalone habitat is incorrect, illustrating the arbitrary nature of the MVP contained in the ARMP and the way it has been applied during the AAG's discussions.

This point is further emphasized when it is realized that an MVP of 2,000 ab/ha is entirely based on the Australian greenlip *H. laevigata* which, at maturity, are only 30 to 50% of the weight of a mature red abalone. The amount of eggs and sperm an animal produces is generally assumed to be proportional to weight, so it can be assumed that adult red abalone produce double or triple the amount of eggs and sperm. At the same population densities these individuals will produce clouds of eggs and sperm several times more dense than the species on which this number is based. So, as noted by Butterworth et al. (2009), we should be dealing in biomass estimates rather than number of abalone per hectare, in which case an MVP of 2,000 greenlip abalone/ha is equivalent to around 700-1,000 red abalone/ha.

Regardless of the arbitrary nature of the limit set for Minimum Viable Population density in the ARMP, the indisputable fact is that the average SMI abalone is spawning at densities four times greater.

5. Addressing the Risk of Allee's Effect

It is within this context that the timing and rate of harvesting has the potential to interact with the natural ability of abalone to maintain themselves in aggregations of sufficient density. This explains the constant theme of over-fishing which Shepherd and Brown (1993), Shepherd and Partington (1995) and Babcock and Keesing (1999) link with their discussion of Allee's effect. In this context Shepherd and Partington (1995) fit Allee's effect into the lower left-hand side of a classical Ricker-type stock recruitment curve to describe a relationship that has compensation at high stock sizes (1.0 – 2.0 ab/m^2), where recruitment becomes limited by competition for resources, as well as depensation (Clark 1974) at low adult densities (0.15 – 0.2 abalone/m^2) whereby recruitment can fail entirely at low levels of spawning biomass. Note that Shepherd and Brown (1993) supported managing for the breeding biomass target of 50% of Full Lifetime Egg Production (FLEP) with the implicit assumption that at higher levels of spawning biomass Allee's effect no longer poses a risk for a population. This original conception of Allee's effect as occurring in a heavily fished population on the left hand limb of a stock recruitment curve is consistent with the movement modeling of Prince (1989, 1992) which showed that at light to moderate fishing pressure the catch rates of the divers were elevated by the re-aggregation of the abalone and the divers' knowledge of aggregation sites. However, at high rates of fishing pressure, abalone are repeatedly fished before they can re-aggregate and catch rates fall. It is in the context of continued overfishing, when population's are held at low densities and prevented from re-aggregating, that the risk of Allee's effect may become real.

Thus the Allee effect is both a product and a symptom of overfishing, and consequently the risk posed by Allee's effect at SMI can be managed by avoiding overfishing and timing harvest to allow spawning to occur in undisturbed aggregations. If heavy fishing, or even lighter pulses of fishing immediately prior to, or during, breeding events, were to be allowed the effectiveness of spawning could be reduced.

It should be noted that Butterworth et al. (2009) suggest that the initiation of an experimental fishery with a 10% take of the surveyed population above 203 mm in the Southwest Zone is a risk-averse strategy, and likely to be well within the level the resource can sustain. This basic outline of a management proposal addresses all local risks voiced by the AAG, and includes monitoring to detect the impact of risks from larger scale effects that cannot be directly managed for. By isolating the fishing trial into just one small region of SMI it is possible to employ mandatory ongoing monitoring to test the range of concerns raised in opening this fishery and end the trial if serious impacts are detected. It is also important to note in their proposal for an experimental fishery the fact that a TAC of 10% of abalone over 203mm in the Southwest Zone removes only 1% of the estimated population at SMI. Three-fourths of the available abalone habitat at SMI will remain outside the fished area and thus outside the local risks posed by the proposed fishery, acting as a de-facto reserve. This will keep FLEP over 80% (Leaf et al. 2008) in the fished area, well above the 50% proposed by Shepherd and Brown (1993).

Thus with the small TAC, limited area of fishing and conservative size limits proposed by Butterworth et al. (2009) the threat of Allee's effect can be effectively managed so that the residual risk is vanishingly small and extremely localized. Meanwhile the required ongoing monitoring and research will document the resource's response and allow for the perceptions of risk to be updated by quantitative data, and also allow for a proactive management response if monitoring reveals a population decline. In this way the residual risk associated with Allee's effect can be managed to zero over a time scale of several years.

To demonstrate this point we explored the size composition data from the 2006 CDFG survey. We created a model to mimic removal through fishing and tested the effect on the distribution of large abalone. We created a bootstrap algorithm to randomly select a legal sized abalone from the SMI 2006 survey data for removal. In order to mimic fishing behavior, the model then searched for and removed any other abalone found within the same 2m by 5m quadrat, or any of the adjacent quadrats (a 120m^2 area). In this way we hoped to replicate the way a diver, upon finding an aggregation, will remove all legal sized abalone in that aggregation, and test the effect of such behavior on the density of the remaining population. Once the simulated diver removes all abalone over 203mm in an "aggregation" (as we have defined it here), the diver randomly chooses another legal sized abalone and continues the process until the quota we have set (up to 70% of the total legal sized abalone) is reached. We calculated both the mean and the 95% confidence intervals from 1000 repeated fishing trials. Figure 3 shows the percent of the population at each density before fishing (black line), as well as the percent of the population at each density after removing 70% of the legal sized individuals (green line, grey lines give the 95% confidence intervals). We chose to show the results of a 70% removal because a 10% removal (the percent removal advocated here) is virtually undetectable as a change in the density experienced by each abalone. Even a 70% removal has very little effect. What little effect a 10% removal would have on abalone density could be mitigated by employing a harvest rule stating that no more than 30% of the legal sized individuals in an aggregation could be harvested.

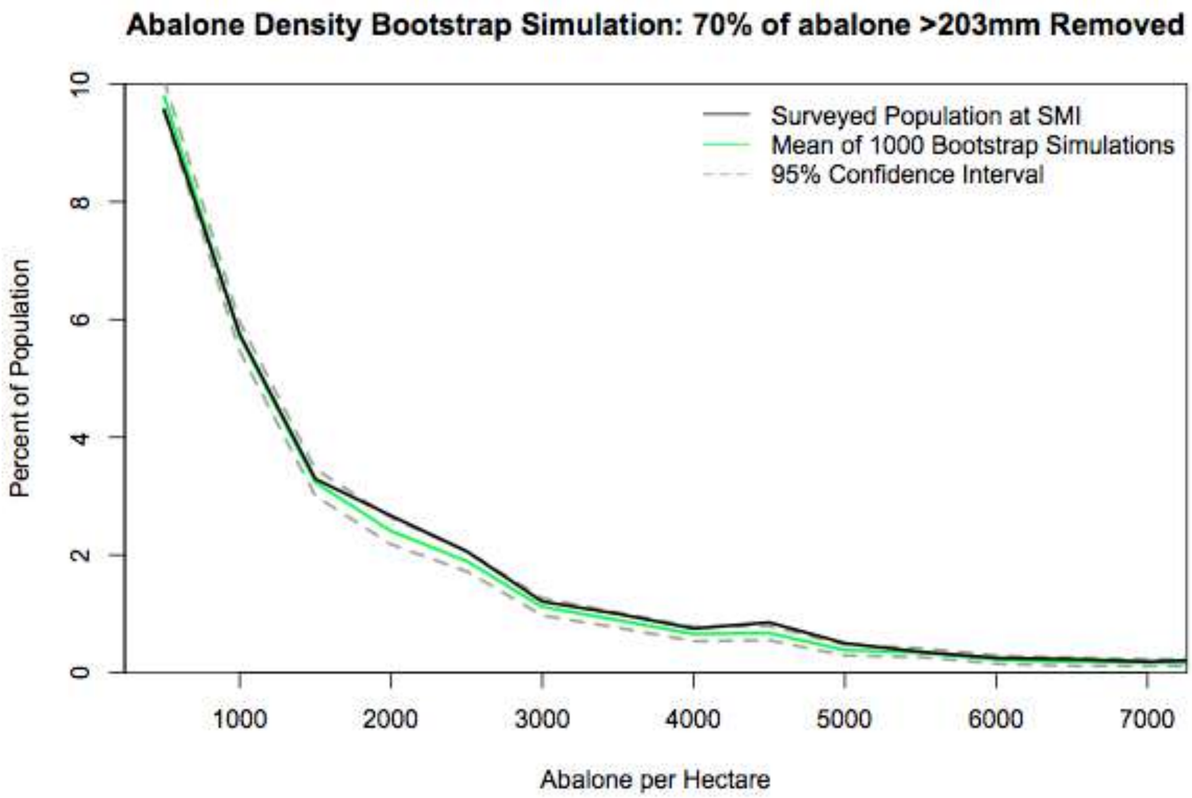


Figure 3. A plot of the percent of the population at each density before fishing (black line), and the change that would occur if 70% of the legal abalone were removed (green line). The grey lines five the 95% confidence interval. The level of 70% removal is used in figure for illustrative purposes, because the 10% proportional harvest scenario cannot be distinguished from the before fishing density structure.

D. Declining Population Modeled by AAG Stock Assessment

The modeling work conducted on behalf of the AAG by Yan Jiao under the guidance of the Technical Panel has added an additional aura of uncertainty and risk to the AAG process. The assessment results purport to indicate that the SMI abalone population has suffered a decline in recruitment over the last couple of decades. However, we argue that this modeled outcome is a result of uncertainty and gaps in the data and changes in data collection protocol over time, and contrary to observed trends over the last 10 years. In addition, the model work was found to be incomplete by Butterworth et al. (2009), a body which included scientists with a great deal of experience with abalone stock assessment models. There is actually no evidence that this modeled result has any basis in reality, as the assessment model has been given no credible data to support a declining trend.

1. Non-Compliance with Accepted Modeling Procedure

Those from outside the field of assessment modeling need to understand that commonly the combination of uninformative data and incorrect prior assumptions will cause the fitting routines to converge on estimates and predictions that make no sense, i.e. negative recruitment or positive mortality rates. In the field of international fisheries assessment modeling it is standard practice to 'tune up' the biological model underlying an assessment by making it sure it doesn't produce such implausible behavior.

One commonly applied method is to test the potential of a stock to rebuild without fishing. It is normal practice to discard model structures that suggest that a stock will continue to decline in the long term without fishing. This normal procedure is exemplified by the following quotations from some of the world's most experienced fisheries assessment modeler's.

> *"The lowest value for steepness was set to 0.25 because He et al. (2006) demonstrated that values for steepness less than this are highly unlikely." Cope and Punt (2009).* (Note: 'Steepness' is defined as the proportion of recruitment produced by 20% of unfished spawning biomass, and is a measure of a stock's ability to replace itself at 20% of virgin biomass.)
>
> *"Most fisheries management is built on the assumption that more or less sustainable yields are possible." Hilborn and Walters (1992).*

The Technical Panel does not appear to subscribe to these views and has instead adopted as its preferred base case a scenario that is fundamentally implausible. This indicates that the Technical Panel may have been biased by the gratuitous applications of the concept of the Allee effect to the population at SMI. This is the only explanation for moving forward with a model that shows a declining population in the absence of fishing pressure.

Working from first principles and excluding disease epidemics or the onslaught of a 'new' key predator like the sea otter, biological populations persist in time by retaining the capacity to increase. In the absence of some 'unnatural' or additional cause of mortality, to propose that an unfished stock continues to decline in the long term is illogical. To illustrate this point one just needs to ask the question: how is that this apparently declining stock came to exist in the first place when it has no capacity to increase from low stock levels? Such a species could never have expanded in the first place to fill the habitat it is currently found in. In the case of the red abalone, after countless millennia of heavy sea otter predation how could such a species build the populations that were first fished in the late 1800s? Logically, without an undetected additional agent of mortality, a stock can only experience a long term decline after it has grown up to and then beyond its climax level and then begins declining back down towards the equilibrium level for that population. Consequently assessment scientists have learned to distrust this dynamic without strong evidence in the data inputs that this is in fact the case.

One could argue that there has been substantial ongoing illegal fishing at SMI since the moratorium, resulting in continued population declines in the absence of a legal fishery, and that the model has detected the effects of this. However, the change in the size distribution of the population since the moratorium (shown below in figure 4) indicates that this is not the case. In 1997 only 1% of the observed population was larger than the size limit, while in 2008 almost half of the emergent population is this size or greater. This shows that abalone have continued to grow at SMI without suffering significant removals of large animals.

As Butterworth et al. (2009) emphasize in their comments, the only reliable information the AAG assessment model contains are the recent survey data, which are of exceptionally high quality. Consequently they recommend relying almost entirely on that data for moving forward, via a decision table assessment of biomass and conservative yields, as developed below. Unfortunately surveys of this quality do not exist throughout the time span this stock has been fished, and in this case the time series data normally required to identify the sorts of trends analyzed by the model are very problematic. So the question becomes: how is the model deriving the result the AAG is using as its base case, and is the basis for it sound? Or alternatively, is it simply an implausible fitting of the model that should have been weeded out early in the process of model development but, due to entrenched beliefs regarding the Allee effect, is in danger of becoming firmly established as 'fact' because now it is the output of a scientific model?

As noted by Butterworth et al. (2009) the modeling conducted has not been reported in a manner that can be easily understood and scrutinized so it is difficult to be certain exactly what has happened:

> *III. 3. The report tabled did not fully explain some of the details of the assessment model, perhaps because it had to be prepared in a very short time; future reports need to provide the specifications of this model in complete detail. Furthermore, such reports should contain summaries that present their conclusions in a form more readily understood by non-specialists.*

2. Bias through Changing Survey Protocols

Despite the obscurity of the modeling it seems almost certain that the outputs suggesting declining recruitment and biomass trends are an artifact of the modeling process driven by assumptions (implicit or explicit) about the selectivity curve which have been used to model the availability of small abalone to the research surveys.

Juvenile abalone are cryptic and hide wedged into crevices and under boulders (Prince et al. 1988). They only begin to emerge into the front of crevices and then out onto reef flats as they mature, where they become available to harvest and are easily sighted in surveys (Prince et al. 1988). Consequently monitoring abundance of juvenile and pre-recruit size classes has always been a difficult issue for abalone science worldwide (e.g. Dixon et al. 2006). If this model was provided with the assumption, either implicitly or explicitly, that a fixed proportion of the smaller cryptic size classes have been found during each survey (i.e. the selectivity curve has remained constant across all the surveys) it will inevitably infer that any changes in the proportion of the juvenile size classes has resulted from a change over time in recruitment rates. It seems certain that the AAG's model has been structured around the assumption that juvenile abalone have been surveyed with the same selectivity and rigor (selectivity curve in modeling language) during every survey, and changes in the proportion of small abalone over time will be interpreted as due to varying rates of recruitment. If recruitment declines for long enough, or far enough, it will also cause the model to estimate a declining trend for adult biomass as well. This logic is hardwired into the Technical Panel's model if it implicitly or explicitly has analyzed the survey data assuming constant selectivity over the surveys.

However, survey protocols with regard to searching for small abalone have changed radically through the years. The original survey protocol in the early 1970s (1974) was simple: swim and count emergent abs. This protocol changed in the 1990s (1993-97). The Cruise report 93-M-6 shows the procedures during timed swims then started including some invasive searching of cryptic habitat targeting juveniles, in addition to counting emergent abalone along survey transects: "When possible, boulders were turned to search for juvenile abalone." Reports 97-M-1 and 97-M-5 also describe the use of these invasive techniques. In 1997 surveys were part of a collaboration with commercial fishermen who were asked to direct CDFG researchers to where juvenile abalone might be easily found and CDFG researchers specifically targeted these areas with the aim of constructing length frequency histograms for the cryptic juvenile size classes (Karpov et al. 1998). In 1999 the protocol changed to counting aggregations, reflecting a growing interest in the Allee effect, and this protocol continued through 2000 and 2001 using the timed swim method, with some searching of cryptic habitats for juveniles, some aggregation counting and only a little transect work. So in these earlier surveys researchers mainly conducted timed swims during which they counted and measured emergent abalone, and then turned boulders looking for juveniles, and there was much less emphasis on swimming along randomly placed transect lines.

By point of reference, since 2006 the survey protocol has been based on randomly placing 60m transects within the boundary of the kelp canopy mapped by aerial photography over several years. Within a 2m wide strip along either side of the 60m transect line, emergent abalone have been counted within 5m segments. There has been no searching of cryptic habitats for juveniles.

Clearly this evolution of survey protocols will have produced marked changes in the actual selectivity curve of the surveys. Without modeling this as a different selectivity curve for each survey protocol, the model will have been constrained to attribute the changes in the proportion of small abalone measured to changes in abalone recruitment, when they were actually produced by changing survey protocols. In this case the length-frequency data from early 1990s, when survey divers searched cryptic habitats for small abalone, and particularly in 1997 where commercial divers told research divers where juveniles would be most easily found, will have been interpreted by the model as indicating a higher previous level of recruitment. The 1997 protocol seems to have been interpreted by the model as a pulse of previous recruitment on top of normal, while the current survey protocol is being an interpreted as continuing current lack of recruitment. According to the logic built into the population model this must over time start decrease estimated adult biomass.

In this way the assumption of the same selectivity curve for all the surveys will have resulted in erroneous estimates of recruitment trends and consequently adult biomass trends as well. The summary points from Butterworth et al. (2009) suggest that they came to a similar diagnosis:

> *III. 2. A flexible functional form should be used to model selectivity-at-length for abalone sampled in the 2006+ surveys, and used in providing model predicted values for proportions at length and abundance corresponding to these surveys.*
>
> *III. 4. "A baseline assessment should be considered based on input from the most reliable data only – likely past catches and the proportions-at-length and abundance estimates from the 2006+ surveys. The effects of adding further relative abundance information should be explored through sensitivity tests."*
>
> *III. 5. More model fit diagnostics should be reported so that the quality of fits can be judged better, and with a view to clarifying which elements of the inputs have the greatest influence on key features of the outputs (such as recent resource trends): for example, both data and model predictions should be compared for each data series input, together with the value of the associated residual standard deviation, for maximum penalized likelihood estimation.*

From the summary points above, regarding:

- flexible functional forms for selectivity curves,
- base-line assessment cases based on 'input from the most reliable data', and
- reporting model fit diagnostics so that the quality of fits can be better judged with a view to clarifying which inputs have greatest influence

Butterworth et al. (2009) found the model runs suggesting declining recruitment and biomass lacked credibility. In Section IV Point 6 they make it very clear that their judgment was that the SMI has, at the very least been stable for the last two decades:

> *IV. 6. The adequacy of the Abalone Recovery management Plan (California Department of Fish and Game 2005) generic minimum-viable-population threshold value of 2,000 abalone per hectare for SMI should be evaluated in the context of 20 years of apparent population stability.*

It should also be noted that the historic time series of length frequency data is more reliable where it pertains to the size range of the larger, fully-emerged and -recruited size classes, because that part of the size structure has not varied with changing survey protocols. In this respect the time series shows that there has been a considerable increase in the proportion of the population larger than the old legal size limit. The percentage of the population larger than 197mm has increased from less than 1% in 1997 (the year the moratorium was enacted) to 47.8% in 2008 (Figure 4). In light of the high fecundity of these large individuals (Rogers-Bennett et al. 2006) one can assume that gamete production has similarly increased in magnitude and that the area their aggregations now cover has grown as well i.e. biomass is growing. This is what commercial, recreational, and research divers alike are uniformly reporting as well.

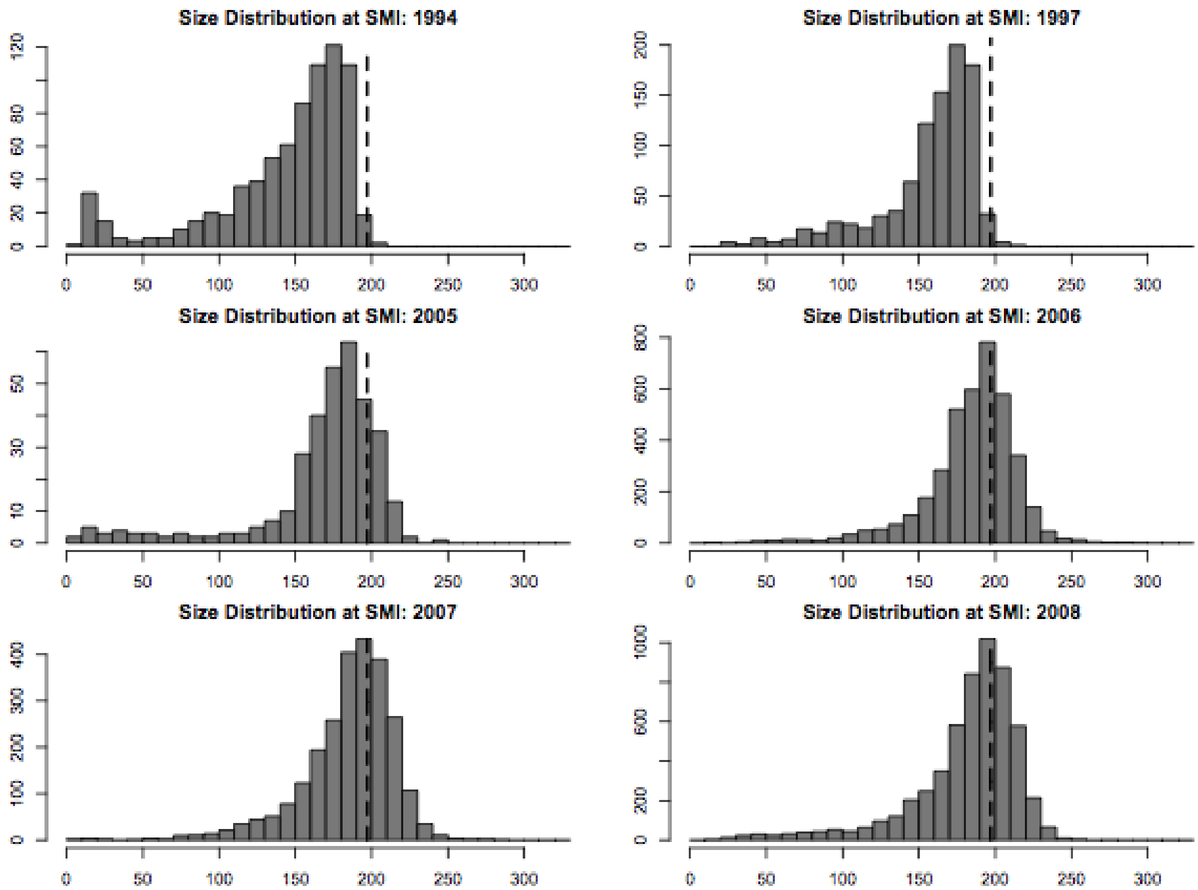


Figure 4. Length frequency histograms (maximum length in mm and number counted) for the abalone surveyed during CDFG surveys 1994-2008.

Discounting the model's estimate of declining recruitment as baseless, and assuming that on average recruitment has stayed stable since the moratorium, as Butterworth et al. (2009) evidently do, these size data suggest that there has actually been considerable growth in SMI breeding biomass since the moratorium stopped fishing (Figure 5).

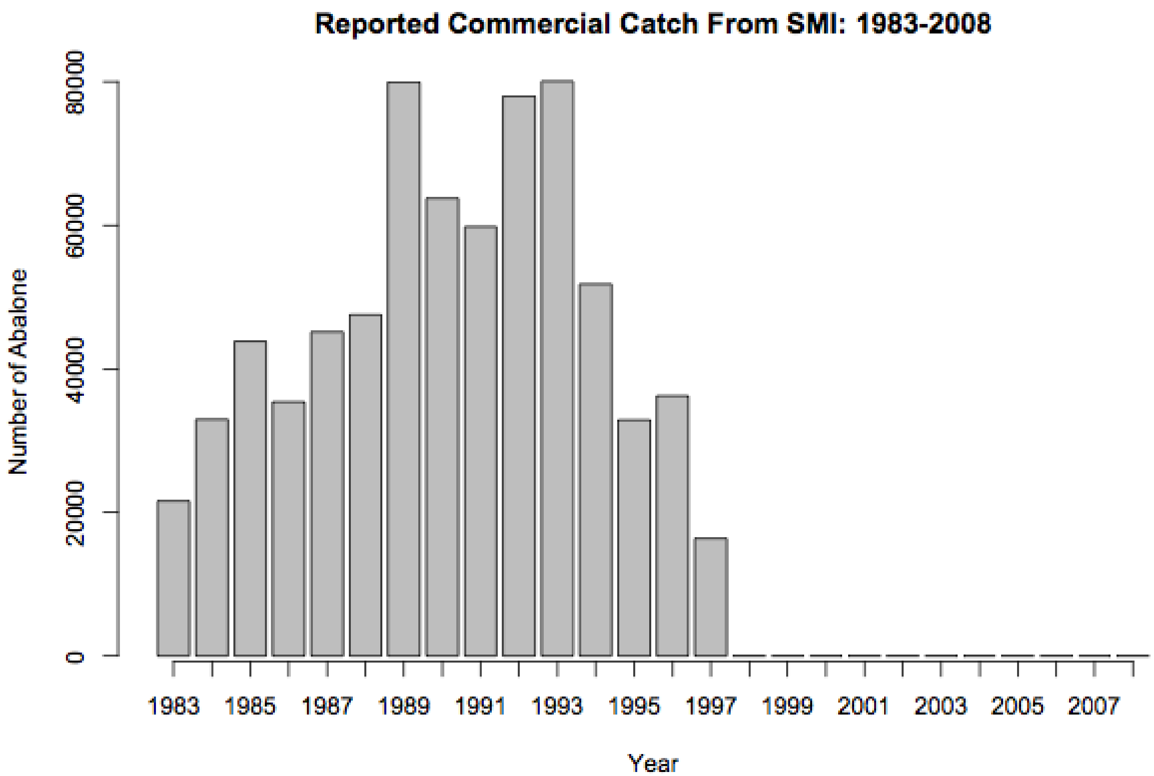


Figure 5. Time series of reported commercial catches (number of abalone) from SMI 1983-1997. *1997 was a curtailed harvest season: 30% of normal years.

This view is supported by an analysis of the CINP data from Wycoff Ledge at SMI (Figure 6), which, despite the inherent variation in the time series, clearly shows that the population has increased at about 10% per year since the fishery closure in 1997, despite starting out at one-tenth the density of the supposed "MVP" of 2,000 ab/ha. A simple exponential growth model was fitted to the Wycoff abundance data before and after the close of the fishery and it estimates the population has grown at an instantaneous rate of 0.1 which, expressed as an annual proportion, is an 9.5% rate of growth since the closure of the fishery in 1997.

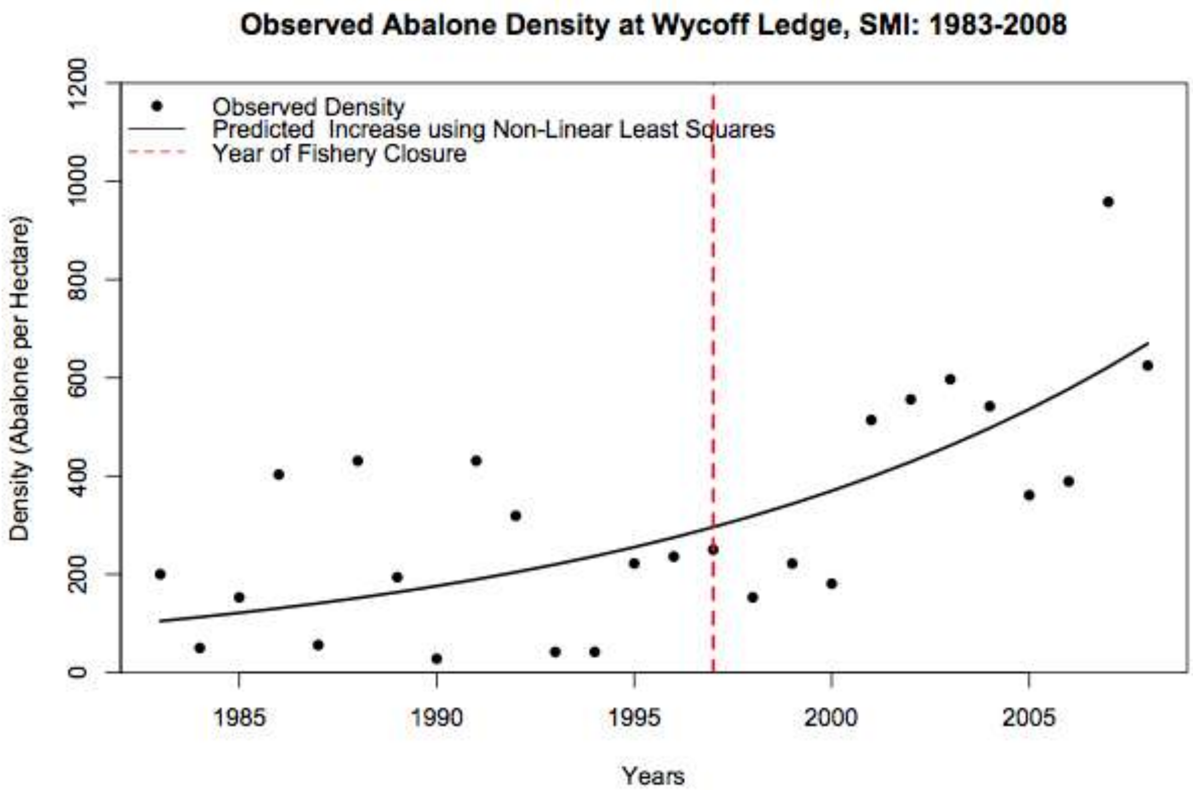


Figure 6. CINP transect counts at Wycoff Ledge at SMI fitted to a simple logistic growth model since the moratorium in 1997 suggests the population has grown at an instantaneous rate of 0.1 since that time.

In figure 6, based on a standardized transect survey protocol which has not changed over time, we get confirmation that the SMI abalone population is behaving consistently with what is expected of the stock on the basis of international fisheries science.

3. Summary on Implausible AAG Model Outputs

In summary, model runs predicting the decline of an unfished stock are inherently implausible and not normally permitted to enter an assessment process without impeccable data showing this to be the case, and only then with significant further testing and clarification as to the drivers of this behavior. The Technical Panel has given no explanation of the drivers behind the purported decline at SMI. In contrast, we have demonstrated that the decline detected by the model is an artifact of using a uniform selectivity across all surveys. This is supported by the National Park data from Wycoff Ledge, which visibly shows a population that has increased from local densities well below the theoretical MVP at a rate of 9.5% per annum since the moratorium, and adds weight to the opinion that this assessment model is flawed, an opinion also advanced by Butterworth et al. 2009.

In consequence we support Butterworth et al. (2009) in placing no credibility on the Technical Panel's modeled outputs, especially not in the suggestions that the SMI has continued declining over the last two decades. Like Butterworth et al. (2009) our interpretation is that the population of SMI has in fact been growing since the moratorium was imposed, so we do not accept the modeler's claim that there is in fact a real risk of decline even without fishing. Any risk posed to the population under harvest can be managed through the limited trial fishery proposed by Butterworth et al. (2009) and by establishing a TAC setting process which will stop harvest if surveying with a standard protocol indicates the purported decline in recruitment and biomass is real and ongoing.

Our goal is a well-managed, long-term sustainable fishery at SMI as well as a healthy red abalone population that continues to rebuild. This can be achieved through the monitoring and management system outlined below, which supports the small-scale trial fishery proposed by Butterworth et al. (2009). This plan requires continued collection of high-quality survey information which will measure trends in recruitment and spawning biomass. If recruitment (or spawning biomass) is found to be declining it will become impossible to sustain any level of catch and maintain the population's current abundance, so the TAC-setting system proposed below will close the fishery. Thus, whatever the actual level of risk associated with this issue, it can be managed within the TAC-setting process by ensuring that a management system is put in place that reduces or stops harvest if those risks are realized.

E. Survey Uncertainty

The ideas outlined above argue that the local risks associated with the proposed trial fishery can be minimized under a level of fishing that maintains current population levels or allows it to continue growing. However, our ability to set sustainable catch levels will be determined by the accuracy of our estimates of the current population and our ability to detect changes in the future. Within the AAG it has been posited that there is a risk that overfishing might inadvertently occur because both our estimates of abundance and the productivity of the SMI stock is imprecisely known. In this section we consider the risk posed by imprecision in the estimate of biomass that have been derived from the surveys, and on which any TAC must be based.

In re-opening a fishery of a resource that is rebuilding, a number of unique challenges are faced. The most commonly published stock assessment techniques are developed to set TACs based on both fishery-independent (observed abundance) and fishery-dependent (catch effort, total catches, and size distribution of landings) data and then analyzing trends in both types of data in the context of what is known about that stock's biology. In the case of a fishery that has never been fished or is to be re-fished after a period of closure, the biology of the species must be used with single (fishery independent) estimate of the population. In the case of SMI the three recent surveys have produced similar estimates, so they can be thought of as replicates of each other. For convenience this paper has worked with the most recent (2008) survey data. This problem has been faced in other abalone fisheries around the world and in Australia the standard approach is construct a decision table so that the uncertainty in expected productivity can be explicitly laid out in tabular form varying with both survey precision and estimates of natural mortality. Over the last few years this approach has been used in South Australia where a large previously unfished area of stock has been added to an Individually Transferable Quota managed fishery (McGarvey et al. 2008). In Victoria, where industry associations closed reefs for three years after a viral epidemic, and are now re-opening them cautiously to re-fishing (Mayfield et al. 2008). While in Western Australia the technique has been used to estimate the lost value of abalone beds from which the fishery is being excluded so an MPA can be established (Hesp et al. 1998). In all these instances commercial divers and research staff have participated in the biomass surveys not unlike the CDFG surveys, and the survey data along with what is known of abalone biology have been used to set conservative levels of production.

The basic principle of fisheries assessment is that a conservative TAC (which should maintain stable stock and recruitment levels, and also allow a stock to build back to optimal levels) can be estimated from the natural turnover rate, or productivity, of the stock. In fisheries biology this is the same as the natural mortality rate (M). By this logic a sustainable take is similar to the natural 'unfished' turnover (M) of the stock (Biomass):

$$TAC = M \times Biomass$$

The issue here is that, in reality, you can never be entirely certain about either M or the Biomass. To address this issue a risk analysis approach has been developed in South Australia (McGarvey et al. 2008, Mayfield et al. 2008) to assess the uncertainty surrounding survey estimates of Biomass associated with both natural productivity and confidence in the survey technique. The uncertainty from each of these two sources are shown in a tabulation of the surveyed population estimate, with alternative natural rates of productivity (M) running down the table, and different possible stock sizes (and their probability given the data) running across the table. This classic decision table format allows management decisions to be made while explicitly addressing risks inherent in estimating a TAC based on a single fishery-independent survey (McGarvey et al. 2008, Mayfield et al. 2008).
McGarvey et al. used aerial photography and topographic maps to define an area of hard-bottom that had never been fished due to its location and the small size of the abalone. They systematically-placed transects in a bounded area and counted and measured emergent greenlip abalone within 1m each side of the transect, finding average density of 0.069 ab/m^2 (690 ab/ha). They used a two-level bootstrap algorithm to estimate the absolute abundance of abalone within the surveyed area, as well as the confidence intervals around that estimate. They tested the ability of

this method to detect a change in abundance associated with fishing by conducting a controlled fish-down and re-surveying the area after fishing. The method showed that they were able to accurately estimate the change in abundance from survey: "The number of abalone removed by harvesters (25,378) fell within a 50% CI, and well within a 95% CI, for the survey-predicted reduction in population of harvestable-sized abalone" (p. 1935, McGarvey et al. 2008). McGarvey et al. and Mayfield et al. (2008) demonstrated the use of this method in quota-setting by developing what they termed a Decision Table, which lists the estimated stock size at various probabilities, as well as the TAC associated with different fishing rates at each level of risk. A variation of this method is also being employed to assess stock recovery and to re-open the fishery after a disease outbreak in the Western Zone of the Victorian fishery (Mayfield et al. in prep).

Butterworth et al. (2009) recommended applying a similar approach to the abalone resource on the southwest of SMI, i.e. using the population estimate at 95% lower confidence interval to mitigate any risk associated with survey uncertainty. The implication of using the lower 95% confidence interval is that we can be 95% certain that the actual number of abalone in that area will be equal to or greater than that estimate. Thus we will be erring on the side of caution with regard to the Biomass inside the trial fishing area when multiplying by our estimate of productivity (M) in setting the TAC.

We have followed this suggestion to derive conservative estimates of the population in the southwest zone of SMI from the 2008 survey data (table 1). We also used the bootstrap approach followed by McGarvey et al. (2008) to estimate the 95 -70% confidence intervals, and used the lower 95% confidence interval in the TAC estimate per Butterworth et al.'s recommendation.

Bootstrapping involves the repeated random re-sampling of the data set of transect counts to derive multiple estimates of mean survey abundance, and then computing the variance within those newly created data sets. We randomly re-sampled the transect counts from the 2008 survey, with replacement, to propagate the variation in the observed transect counts through to the estimate of absolute abundance, regardless of the underlying distribution of the data points. We deviated slightly from the approach used by McGarvey et al. (2008) in that we treated the two reciprocal transects at each randomly chosen survey site as a single 60 x 4m quadrat rather than treating each of the two transects at each site as independent, because we found that paired transect counts are highly correlated. We sampled from these 60 x 4m abalone counts to create 10,000 new data sets, each a dataset that could have potentially been observed at SMI, and used these to calculate 10,000 potential mean density values. We then used this distribution of means to determine the risk probabilities and created a decision table for SMI (Table 1). Looking across the top two rows of Table 1 one can see the population estimates derived from the 95-70% confidence intervals. The top row contains the estimate of the total emergent population and the second row contains the estimates for the population > 203mm (or 8 inches).

Based on the distribution of transect observations, there is a 95% probability that the absolute abundance of emergent abalone in the southwest zone is equal to or greater than 320,220, and that 107,278 of those were >203mm in 2008.

F. Uncertainty Regarding Productivity (M) and Sustainable Rates of Harvest

The logic outlined above is that through management decisions the local risks created by the proposed trial fishery can be explicitly reduced. The uncertainty in the statistically estimated stock size has been estimated in Table 1. This raises the issue of what level of productivity (M) should be assumed. The AAG's meeting documents record their concern that overfishing will inadvertently occur because estimates of the productivity of the SMI abalone are imprecisely known. However there is a broad body of science about the natural mortality rate of abalone.

The influence of the assumption about M is displayed in Table 1 running down the rows 0.05 to 0.35, which may also be referred to in this document as a percentage (i.e. 5-35%). M is synonymous with the terms productivity, turnover rate, harvest fraction, and (by Butterworth et al. 2009) proportional-take. Running down a column in Table 1 shows the implication for the TAC calculation of what you assume about proportional-take. Shepherd and Breen (1992) provide what is still the most thorough review of the international literature on the estimation of mortality rates for abalone, particularly with regards to studies of wild populations. They emphasize the variability in mortality rates observed between species, age, habitat, density and other environmental differences. Natural mortality rates decline with increased age/size before stabilizing at low levels in the emergent adult population. Shepherd and Breen (1992) attributed the variability between species to both latitudinal differences, with colder water having lower mortality rates, and differing assemblages of predatory species. They hypothesized that colder water species such as *H. kamtschatkana* and *H. iris* have lower adult mortality rates (0.1-0.2) while warmer water species such as *H. marae*, *H. corrugata*, *H. fulgens* and *H. laevigata* have higher adult mortality rates 0.25-0.35, with *H. rubra* being between those groups. Inconveniently they leave the red abalone *H. rufescens* from their list but one presumes from the various Californian studies that its mortality rate lies somewhere between these extremes.

Butterworth et al. (2009) were clear on their opinion about this topic: "Given such a relatively high age at first capture, this 10% proportional take is well below standard fishing mortality reference points." What they are referring to is equating the proportional take of 10% with an estimate of natural mortality (M) considered by science to be the lowest end (M=0.1) of the range of estimates in the literature (0.1-0.35) even though the red abalone is thought to be more productive than that. Of course local management strategies can be made even more precautionary by choosing a lower rate of harvest with which to set the TAC, and so explicitly assume even lower rates of natural turnover in the stock.

In this context it should again be remembered that under this proposal, supported by Butterworth et al. (2009), the TAC is for one year and harvest will only occur in the southwest zone of the SMI. The rest of the island would not be harvested. But stocks around SMI would continue to be monitored with surveys so changes in surveyed biomass would change the following TAC. In this broader low-risk context it can be argued that very little additional adjustment for risk is needed in establishing the agreed upon harvest rate. This is undoubtedly the same logic Butterworth et al. (2009) used in coming to their recommendation that a 10% harvest rate would be conservative for the SMI population.

Applying Butterworth et al.'s (2009) suggestion of a 10% harvest rate of the lower 95% confidence estimate of the population in the southwest zone greater than 203mm, we recommend an initial TAC of 10,728 abalone (Table 1). In this manner we can use the uncertainty in the survey estimates to set a precautionary TAC, thus mitigating the risk of overestimating the population in the southwest zone to only 5% and using the lowest observed rate of natural mortality for any abalone species anywhere in the world.

Total Population In SOUTHWEST Zone	320,220	335,562	345,560	353,252	359,640	365,186
Population> 203mm	107,278	112,418	115,767	118,344	120,484	122,342
Harvest Fraction	**95%**	**90%**	**85%**	**80%**	**75%**	**70%**
0.05	5,364	5,621	5,788	5,917	6,024	6,117
0.1	10,728	11,242	11,577	11,834	12,048	12,234
0.15	16,092	16,863	17,365	17,752	18,073	18,351
0.2	21,456	22,484	23,153	23,669	24,097	24,468
0.25	26,819	28,104	28,942	29,586	30,121	30,586
0.3	32,183	33,725	34,730	35,503	36,145	36,703
0.35	37,547	39,346	40,518	41,420	42,169	42,820
0.4	42,911	44,967	46,307	47,338	48,194	48,937

Table 1. A Decision Table based on the 2008 SMI survey data showing how estimates of a sustainable TAC varies with increasing the level of uncertainty in the survey estimate; across the columns we are 95-70% certain that actual abundance is greater or equal to the survey estimate in that cell. The TAC estimate increases as the assumed productivity (M) increases down the rows. The top row contains total emergent population estimates for the southwest zone of SMI. In the second row are the estimates for the population >203mm or 8 inches. All subsequent rows are calculated using the >203 population.

IV. Risk Management and a Way Forward

Having reviewed the various sources of uncertainty and risk that have been raised in the discussions of the AAG with regard to setting a TAC for SMI we can see that several issues, namely disease and otter encroachment, must be principally managed in the broader state wide context with the other Californian stocks, and locally by using monitoring to ensure that fishing does not compound declines that might occur in the future due to disease or otter encroachment.

At the local scale, the risks associated with the trial fishery, i.e. Allee effect, model uncertainty and general lack of knowledge, can all be managed by allowing a closely monitored trial fishery on a small sub-section of SMI and setting a TAC for the trial fishery which ensures a low exploitation rate and high certainty based on the high quality recent survey data.

As Butterworth et al. (2009) concluded in Section IV. Risk Considerations and Computations:

> *7. [If the MVP value from the ARMP and interpreted by the AAG is used it] would effectively preclude re-opening an abalone fishery at SMI at present. However, initiation of an experimental fishery that (for example) is restricted to the Southwest Zone and taking only 5-10% of the population above 203 mm is a risk-averse alternative, and likely to be well within the level the resource could sustain.*

Butterworth et al. (2009) also mapped out the way forward (Section V):

> *1. A program of experimental fishing should be considered for the Southwest Zone as an initial step in pursuing the options for removals. If specific sustainability criteria are met then this might subsequently be expanded in a stepwise post-moratorium process that is consistent with the Abalone Recovery and management Plan (CDFG 2005). An increased minimum legal size would provide additional resource protection without unduly reducing the available stock. For instance, if set to 203mm as tabled in the SMI survey report, the stock size would be 9-15% less than at the current minimum legal size of 197mm. A conservative risk-averse approach could be based on the 95% lower confidence level of the estimated abundance from the 2007 abundance survey. For instance, an experimental TAC of 8,300 red abalone would provide a viable harvest whilst leaving 90% of the available stock (to which recruitment would be added next year). Given such a relatively high age at first capture, this 10% proportional take is well below standard fishing mortality reference points."*
>
> *2. The experimental harvest could be timed to occur during a defined period allowing for weather and market considerations. This would ensure that concerns regarding regulatory compliance could be more easily satisfied without undue costs."*
>
> *3. The Southeast Zone should remain as an unfished control region that enables the detection of changes in abundance caused by environmental effects. This region could also be used as a source for brood-stock transplantation as per the option for a non-consumptive TAC."*
>
> *4. If an experimental commercial harvest is implemented, then recreational stakeholders should be provided with equitable resource access without compromising the integrity of the experimental strategy".*

A. Establish Assessment Framework and TAC Decision Rules

Furthermore Butterworth et al. (2009) laid out what should be the next steps (Section VII. Next Steps):

> *"If the approach outlined above for a possible way forward is taken further, there are certain prerequisites to implementation and permitting removal of abalone.*
>
> > *1. The details of a monitoring program must be specified and agreed to.*
> > *2. A power analysis must be conducted to confirm that the monitoring will be able to detect effects of importance, in particular that of reduction in abundance as a result of removals.*
> > *3. The statistical catch-at-age assessment methodology should be advanced in line with the advice given above, and used in projection mode to estimate the range of possible consequences for SMI abundance of any level of removals that comes under consideration"*

V. The Future Management System

Anticipating the need for these next steps the Executive Board of the CAA met at UCSB on 8 December 2008 with me (Prince), UCSB academics, and CDFG officials including John Ugoretz to develop a blueprint for a future management system that they could begin developing with help from UCSB.

The CAA had requested Joe Sullivan, who has experience the formation of Fishing Industry Co-operatives in Alaska for the purpose of fisheries management, to advise them on the way forward. The meeting considered a document he had prepared for them. Sullivan had outlined three components of Cooperative development as follows:

- A regulatory limited access program that defines the class of divers eligible to participate, and defines the key characteristics of their limited entry licenses – i.e., duration, transferability, etc.
- A regulatory framework for co-management – i.e., substantive definition of a cooperative's fishery management authority and its related performance standards, cooperative allocation eligibility criteria, and procedures for making an application for an allocation and making annual performance reports.
- A cooperative that has the institutional capacity to perform co-management responsibilities implying both capacity for the organization and technical feasibility in the data gathering, assessment, and management procedures.

The focus of the meeting was fleshing out the technical detail of the third component, and what follows builds on the recommendations developed during that meeting.

A. Recommended Process for SMI Abalone

1. Set a TAC with the Decision Table

Similar to the recommendations of Butterworth et al. (2009) the meeting agreed that the Decision Table approach as applied in South Australia by McGarvey et al. (2008) provided a solid risk averse means of establishing an initial TAC for the trial fishery. This document has followed the suggestions of Butterworth et al. (2009) to minimize the risk of over-fishing, and used the results of the 2008 survey to estimate a TAC of 10,728 red abalone (>203mm) from the southwest zone of SMI.
This Decision Table approach could be set into regulation and based on an annual or bi-annual survey used to annually set the TAC until an enhanced integrated approach to TAC setting based on modeling time series data is proven, accepted and incorporated into regulation.

2. MOU with Harvesting Cooperative.

Through consultation with recognized expertise in the field the CDFG should specify the standards to which the SMI resource is to be managed, and protocols for data collection and analyses, along with how they will be used to determine TACs. A Memorandum of Understanding (MOU) should then be developed with harvesting cooperative/s allowing for CDFG to agree to annual TAC's provided they are is satisfied that the standards agreed under the MOU are being met by the harvesting cooperative/s.

3. Annual Surveys and Disease Testing

The meeting referenced above found that, at least initially, density and size data will need to be collected every year. In the long-term there will need to be some thought given to making the data collection process as cost effective as possible. In the medium- to long-term income from harvesting must be able to support the cost of operation including the annual survey event. This is a key issue faced by fisheries managers all over the world; how to efficiently survey catch and population changes over the broad spatial scales that many fisheries take place. The problem is compounded by the patchy nature of abalone, which results in high variances in fishery-independent surveys and makes statistical power to detect change that much harder to achieve.

A power analysis completed on the survey data from 2006 to 2008 shows that, with the current variance in the data, in order to detect a difference in means of 20% from year to year with 80% probability more than three times as many independent observations are needed. Abalone managers around the world have attempted to address this problem, and a number of papers have been written comparing different fishery-independent survey methods (McShane 1994, Tarr et al. 2000, Andrew et al. 1996, Gorfine et al. 1998, McGarvey et al. 2008). There has been much debate regarding fixed vs. systematic vs. random transects, how to choose survey regions, and stratification. A recent Australian research project (Mayfield et al. in prep) has been very successful in reducing the variance associated with abalone surveys using diver knowledge. With this approach divers have used their knowledge to map the main concentrations of abalone on the fishing grounds, and these maps have been the basis for the first level of survey stratification, with sampling being concentrated within the nominated areas of high density, and a much lower level of sampling dispersed across the areas known to contain little biomass. Australian studies are also examining the use of GPS technology to track the search area of commercial divers and the early indications are that this technology may provide a reliable and cost effective means of tracking abundance as a function of catch per area swept, rather than the discredited index of catch per unit of diving time. These initiatives suggest there is considerable promise in the medium-term future for improving both the precision and cost effectiveness of monitoring abalone abundance in California.

4. Application of a Decision Tree and Meta Rules to Annual Set TACs

In the medium-term a specific "Decision Tree" should be developed for red abalone at SMI based on maintaining the surveyed density of the abalone and their size structure at target levels which will ensure high levels of breeding biomass are maintained. It should explicitly incorporate a conservative management approach of 50-70% of Spawning Potential Ratio (SPR), which is the proportion of spawning conserved in a fished population relative to the level of spawning expected if the population was left unfished.

Worldwide, fisheries biologists and managers are recommending that SPR targets of 30-50% should conserve fish stocks, so a target of 50-70% should build in a precautionary margin for environmental variability, poaching, and other extreme events that might increase rates of natural mortality. *Nota bene*: Shepherd and Brown (1993) who first raised the issue of the Allee's effect for abalone supported a local target SPR of 50%. With this type of target the SMI abalone population should be able to continue re-building even in a worst-case scenario. The Decision Tree would be used to assess the stock relative to the target level of SPR and revise the annual TAC upwards or downwards depending on whether the stock was above or below the spawning biomass target.

Having established an initial TAC for a trial fishery, provision should be made within that TAC to gather size structured samples so that the local relationships between length, width, height, weight and fecundity studies can be described and SPR models developed so that a Decision Tree can be conditioned on data from the southwest zone of SMI.

Special over-riding decision rules involving a cessation of fishing should also be incorporated into to the annual TAC setting process so that, in the event of a disease outbreak, or otter predation, fishing pressure does not exert additional pressure on the abalone stock within the trial fishery.

5. Structured and Controlled Annual Harvest

While regulations regarding harvesting might allow for harvesting to take place all year round, the harvesting cooperative will foster confidence in the fishery and make the processes of data collection and enforcement more cost-effective by developing and coordinating a structured, controlled annual harvest. In this way annual surveys and harvests could be conducted within a short space of time, or several short harvesting sessions, which CDFG research and enforcement personnel could plan around. This approach will lead to greater transparency and cost efficiencies for the processes of stock and catch monitoring

During harvesting, fishery-dependent data will be collected by the fishermen using the Harvest Log created by the CAA. These logbooks collect the full range of fisheries data including dive positions, time and duration, catch in total number, size and weight. The GPS technology being deployed in the Australian fishery to document dive tracks will also be deployed and the size profile of the catch will be monitored.

6. Increased Size Limit

An increased 8 inch size limit is suggested on the basis that it would conserve higher levels of breeding potential in each aggregation by reducing the number of legal size abalone in each aggregation and so force divers to search a larger area to fill their individual catch targets. Shepherd and Partington (1995) documented how an increased size limit resulted in a larger aggregations being left after harvesting along with a larger average size amongst the remaining abalone.

The other rationale underlying this recommendation is that the recent Australian experience has shown that size of maturity varies markedly between populations, and many of the original scientific studies of size of maturity occurred in relatively sheltered locations and lees, which are characterized by their relatively small size of maturity. In time it may be found that the original legal size limit may not have been conservative for many of the main commercial abalone beds in southern California. In this case it would be precautionary to trial an increased size limit for the trial fishery at SMI. The abundance and size composition data from the surveys show that the suggested TAC will be easily filled with abalone above that size which will avoid excessive handling of abalone just below the measure.

7. Ocean Protection Council (OPC) Grant

The CAA with support from the CDFG should develop an application for OPC funding to support a University of California at Santa Barbara student who can:

- Provide technical support to develop the "Decision Tree" for SMI red abalone
- Develop modeling concepts
- Provide technical support for data gathering (including stereo video)
- Develop system for storing and using data

References

Ault, J.S. and J.D. DeMartini. (1987). Movement and Dispersion of red abalone *Haliotis rufescens*, in Northern California. *Cal. Fish and Game* 73: 196-213

Babcock. R., and J. Keesing. (1999). Fertilization biology of the abalone Haliotis laevigata: laboratory and field studies. *Can. J. Fish. Aquat. Sci.* 56: 1668-1678

Berkes, F., R. Mahon, P. McConney, R.C. Pollnac and R.S. Pomeroy. (2001). *Managing Small-Scale Fisheries*. International Development Research Centre, Ottawa.

Breen, P.A. and B.E. Adkin. (1980). Spawning in a British Columbia population of northern abalone, *Haliotis kamtschatkana*. *The Veliger* 23: 177-179

Butterworth, D., H. Gorfine, S. Schroeter and E Weber. (2009). Evaluation of the Red Abalone Stock Assessment by the Review Committee in the Support of Deliberations of the Abalone Advisory Group. La Jolla, California 17-18, February 2009

Campbell, A. (2000). Review of northern abalone, Haliotis kamtschatkana, stock status in British Columbia. *In* Workshop on rebuilding abalone stocks in British Columbia. *Edited by* A. Campbell. *Can. Spec. Publ. Fish. Aquat. Sci*. 130: 41-50

Cope, J.M. and A.E. Punt. (2009). Length-based reference points for data-limited situations: applications and restrictions. *In* Proceedings of the Californian Sea Grant Workshop on Managing Data-Poor Fisheries: Case studies, models and solutions. Berkeley 1-4 December 2008. pp. 30.

Culley, M. and K. Sherman. (1985). The effect of substrate particulate size on the production of mucus in *Haliotis tuberculata* L. and the importance of this in a culture system. *Aquaculture* 47: 327-334

Davis, G. E. (2000). Refugia-based strategies to restore and sustain abalone *Haliotis* spp. populations in southern California. *In* Workshop on rebuilding abalone stocks in British Columbia. *Edited by* A. Campbell. *Can. Spec. Publ. Fish. Aquat. Sci*. 130: 133-138

Davis, G.D., P.L. Haaker and D.V. Richards. (1996). Status and trends of white abalone at the California Channel Islands. *Trans. Am. Fish. Soc.* 125: 42-48

Dixon, C.D., H.K. Gorfine, R.A. Officer and M. Sporcic. (1998). Dispersal of tagged blacklip abalone, Haliotis rubra: Implications for stock assessment. *J. Shellfish Res.* 17: 881-887

Dixon, C.D., R.W. Day, S.M.H. Huchette and S.A. Shepherd. (2006). Successful seeding of hatchery-produced juvenile greenlip abalone to restore wild stocks. *Fish. Res.* 78: 179-185

He, X., M. Mangel and A. MacCall. (2006). A prior for steepness in stock recruitment relationships based on an evolutionary persistence principle. *Fish. Bull.* 104: 48-433

Hesp, A., N. Lonergan, N. Hall, H. Kobryn, A.M. Hart, F.P. Fabris and J. Prince. (2008). Biomass and commercial catch estimates for abalone stocks in areas proposed as sanctuary zones for the Capes Marine Park. Western Australian Fisheries Department. Fisheries Research Report N. 170. pp 52.

Hilborn, R., and C.J. Walters. (1992). *Quantitative Fisheries Stock Assessment: Choice, Dynamics, and Uncertainty.* (Chapman & Hall: New York)

Jamieson, G.S. (2000). Marine protected areas and their relevance to abalone (Haliotis kamtschatkana) conservation in British Columbia. *In* Workshop on rebuilding abalone stocks in British Columbia. *Edited by* A. Campbell. *Can. Spec. Publ. Fish. Aquat. Sci*. 130: 139-148

Karpov, K.A., P. Haaker, D. Albin, I.K. Taniguchi and D. Kushner. (1998). The red abalone, *Haliotis rufescens*, in California: Importance of depth refuge to abalone management. *J. Shellfish Res.* 17: 863-870

Karpov, K.A., P. Haaker, I. Taniguchi and L. Rogers-Bennett. (2000). Serial depletion and collapses of the California abalone (*Haliotis* spp.) fishery. *In* Workshop on rebuilding abalone stocks in British Columbia. *Edited by* A. Campbell. *Can. Spec. Publ. Fish. Aquat. Sci.*130: 11-24

McGarvey, R., S. Mayfield, K. Byth, T. Saunders, R. Chick, B. Fourer, J.E. Feenstra, P. Preece and A. Jones. (2008). A diver survey design to estimate density, biomass, and spatial distribution. *Can. J. Fish. Aquat. Sci.* 65: 1931-1944

Mayfield, S., R. McGarvey, I.J. Carlson and C. Dixon. (2008). Integrating commercial and research surveys to estimate the harvestable biomass, and establish a quota, for an "unexploited" abalone population. ICES *J. Mar. Sci. Avd. Acc*. 26: 1-9

Mayfield, S., R. McGarvey, H.K. Gorfine, H. Peeters, P. Burch and S. Sharma. (2009). Biomass of blacklip abalone *(Haliotis rubraI)* between Pt Fairy and the Crags. In the Western Zone of the Victorian abalone fishery. SARDI Publication No. F2008/000958-1

McShane, P.E. (1995). Recruitment variation in abalone: its importance to fishery management**,** *Mar. Freshwater Res.* 46: 555-570

Officer, R.A., C.D. Dixon and H.K. Gorfine. (2001). Movement and re-aggregation of the blacklip abalone, Haliotis rubra Leach, after fishing. *J. Shellfish Res.* 20: 771-779

Prince, J.D. (1989). The fisheries biology of the Tasmanian stocks of *Haliotis rubra*. PhD Thesis. University of Tasmania, Australia.

Prince, J.D. (1992). Exploring the dynamics of abalone fisheries using a spatial model of an exploited stock of *Haliotis rubra*. *In* Abalone of the world: biology, fisheries and culture. *Edited by* Shepherd S.A., Tegner, M.J., Guzman del Proo, S.A. Blackwells, Oxford. 744 pp.

Prince, J.D., T.L. Sellers, W.B. Ford, and S.R. Talbot. (1988). Recruitment, growth, mortality and population structure in a southern Australian population of *Haliotis rubra* (genus Haliotis ; Mollusca : Gastropoda). *Mar. Biol.* 100: 75-82

Prince, J.D., C. Walters, R. Ruiz-Avila and P. Sluczanowski. (1998). Territorial user's rights in the Australian abalone fishery. *In* Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. *Edited by* G.S. Jamieson and A. Campbell. *Can. Spec. Publ. Fish. Aquat. Sci.*125: 367-375

Shepherd, S.A. and P.A. Breen. (1992). Mortality in abalone: its estimation, variability and causes. *In* Abalone of the world: biology, fisheries and culture. *Edited by* Shepherd S.A., Tegner, M.J., Guzman del Proo, S.A. Blackwells, Oxford. 744 pp.

Shepherd, S. A. and L. D. Brown. (1993). What is an abalone stock: Implications for the Role of Refugia in Conservation. *Can. J. Fish. Aquat. Sci.* 50: 2001–2009

Shepherd, S. A. (1986a) Studies on Southern Australian abalone (genus *Haliotis*) VII. Aggregative behaviour of *H. laevigata* in relation to spawning. *Mar. Biol.* 90: 231-236

Shepherd, S. A. (1986b). Movement of the southern Australian abalone *Haliotis laevigata* in relation to crevice abundance. *Aust. J. Ecol.* 11: 295-302

Shepherd, S. A. and D. Partington. (1995). Studies on Southern Australian abalone (genus *Haliotis*) XVI. Recruitment, habitat and stock relations. *Mar. Freshwater Res.* 46: 669-80

Stekoll, M.S. and T.C. Shirley. (1993). *In situ* spawning behavior of an Alaskan population of Pinto abalone, *Haliotis kamtschatkana* Jones, 1845. *The Veliger* 36: 95-97

Tarr, R.J.Q. (1995). Growth and movement of the South African abalone *Haliotis midae*: A reassessment. *Mar. Freshwater Res*. 46: 583-590

Tegner, M.J., P.A. Breen and C.E. Lennert. (1989). Population biology of red abalone, *Haliotis rufescens,* in Southern California and management of the red and pink, *H. corrugata*, abalone fisheries. California Department of Fish and Game. *Fish Bull.* 87: 313-339

Tegner, M.J., L.V. Basch and P.K. Dayton. (1996). Near extinction of an exploited marine invertebrate. *Trends Ecol. Evol.* 11: 278–280

Tegner, M.J. (2000). Abalone (*Haliotis* spp.) enhancement in California: what we've learned and where we go from here. *In* Workshop on rebuilding abalone stocks in British Columbia, *Edited by* A. Campbell. *Can. Spec. Publ. Fish. Aquat. Sci*. 130:61-71

Withler, R.E. (2000). Genetic tools for identification and conservation of exploited abalone (*Haliotis* spp.) species**.** *In* Workshop on rebuilding abalone stocks in British Columbia. *Edited by* A. Campbell. *Can. Spec. Publ. Fish. Aquat. Sci*. 1

APPENDIX H: 2009 SURVEY PROTOCOL FOR SAN MIGUEL ISLAND (SMI)

The primary goal of this survey method is to detect changes in year-to-year (relative) abundance between impact areas (fished) vs. control areas (unfished). This approach sets up a Before-After-Control-Impact (BACI) experimental design that will help evaluate impacts on red abalone (*H. rufescens*) stocks on the southwest side of San Miguel Island (SMI). The procedure outlined here draws on methods currently used to monitor fished stocks in Victoria and South Australia and adapts them to best fit red abalone ecology and the logistics at SMI.

1. Selection of Survey Areas

Areas will be surveyed that exhibit abalone densities that could potentially support a sustainable commercial fishery. Using the previous three years of survey data and utilizing knowledge of the area from commercial fishermen and biologists, four survey sites were chosen: 1) two in the Southwest zone, which will be the location of a pilot fishery, 2) a reference site in the Southeast zone, which would remain unfished during the pilot fishery, and 3) a site in the Judith Rock marine reserve, in which all commercial and recreational fishing is banned. Each site consists of 10-12 micro-blocks (approximately .1 square nautical mile) of kelp forest habitat. See Figure 2 for sample station map

2. Selection of Survey Stations

Potential survey stations were produced by generating GPS coordinates for up to four (4) stations per micro-block depending on available kelp habitat. From these possible survey stations, two (2) stations per block were randomly selected for this year's survey based on a projected survey effort of 80 stations over a three day survey period. The other two (2) stations per block will serve as alternate points. These stations will be surveyed provided they can be accessed safely due to weather, current, and other considerations, and provided they appear to adequately represent abalone habitat. If a station is not used an alternate station location is provided. Once divers descend they will complete four (4) transects, in the shape of a cross, regardless of bottom habitat.

3. Transect Methodology

a) Required Equipment

Each diver, in addition to normal diving safety equipment, shall have the following equipment in order to complete a survey:

(1.) Watch
(2.) Depth gauge

(3.) Compass
(4.) Measuring calipers
(5.) 1 meter PVC stick
(6.) Data sheets (may include sheets for several dives)
(7.) Slate to hold data sheet
(8.) Pencil
(9.) Forestry crayon

Each dive team will have the following equipment in order to complete a survey:

(1.) GPS unit (on boat)
(2.) Descent line with anchor and float
(3.) Transect line or tape

b) Transect Line

The transect line is a 30m long line or tape on a reel. When the line is deployed, the reel is on the "30m" end of the transect line. The line is marked at each 5m increment. This pattern will assist the divers in recording the data into 5m segments. A transect line will be laid at a pre-determined station, where a dive team will run the survey. The extended transect line is used to guide the divers over a 30m long by 1m wide area on each side of the line. The 1m distance from the transect line is measured by the use of a 1m long PVC stick (Figure 3).

c) Transect Line Deployment

The direction (Transect Heading) is determined before the dive and pre-printed on the datasheet. The transect line is deployed in as straight a line as possible on the transect heading. Secure and begin deploying the 30m transect 5m from the weight of the station-marker buoy line on the same heading as transect. When the line is completely deployed, the reel or line is again secured. A clip on the reel or line can be used to secure it to kelp or a rock can be used to anchor the reel/line end.

4. Survey Procedures

The captain of each dive vessel will use a GPS for navigation to assigned stations, and verify site location prior to diving. A line attached to a weight will be deployed precisely at latitude and longitude coordinates of stations. At each station four (4) transects will be completed in the form of a cross. Compass headings for transects on a station were determined by random selection and are printed on the datasheets. The compass headings for the other three transects are set at 90-degree intervals from this primary heading. For example, if the first heading is 240^{o}, the reciprocal heading will be 60°. The next set of transects for this station will have headings of 330° and 150°. Divers will work in pairs, and conduct two (2) reciprocal transects per station.

Information on block, grid, site number, site location (latitude/longitude), and headings are printed on the data sheets. Divers must record diver names, date, and transect orientation (Left or Right side of transect) on the data sheets prior to descending. Diver pairs will descend with a transect line or tape, two 1-meter long reference rods (to define transect width), calipers, and slates with attached data sheets The weight of the station-marker line will provide a central starting point for all four (4) transects. Divers will begin to roll out their transect line along the pre-determined compass heading five (5) meters from the central starting point. The diver pair will then swim along the transect line to record data, with one diver on each side of the transect line.

Each diver will be responsible for counting all visible abalone encountered and recording habitat within one (1) meter of the transect-line on their side of the line. Dive teams will then roll up the transect line and repeat the procedure along a reciprocal compass heading. Divers will complete all transects (regardless of habitat/ bottom type) provided they can safely do so. In the event that a survey station or part thereof cannot be completed, due to a drop off, prolonged shallow area, or other environmental hazard, make a notation of the circumstances on the data sheet, and move to the next station site.

Do not re-use a pre-printed datasheet from an aborted survey site. An aborted station sheet is to be returned to the Data Manager with comments. If you survey an alternate site use a blank datasheet and fill in all fields normally pre-printed.

5. Abalone Length-Frequency and Abundance

All abalone encountered on transect will be counted with a tick mark in the appropriate 5m segment. The first 15 abalones encountered along each side of transect will be measured using calipers. The length (in millimeters) and transect segment (1-6) in which they are found will be recorded.

a) Abalone Data

(1.) The first 15 measurable red abalone encountered on the line are measured (*See: Measuring and Identifying abalone*) with calipers and recorded in the respective boxes on the data sheet. The first 15 abalone measured and all other abalone along the line are counted and recorded with a tick in the respective 1m x 5m section of the data sheet.

(2.) All observed abalone are included in the survey, even those in crevices and under ledges found without the use of a light.

(3.) Abalone that occur near the edge of the one meter area are counted as long as some portion of the abalone falls within the one meter area
(4.) Abalone other than red abalone will be measured and noted by the addition of an identifying letter to the measurement ("F" – flat abalone, "P" – pinto abalone, "Pk" – pink abalone). These abalone species are not part of the first 15 measured red abalone.
(5.) Each abalone should be marked with a forestry crayon so that abalone will not be re-measured inadvertently.
(6.) Abalone data are recorded by 1m x 5m segments along the transect line.

b) Habitat and Depth

Diver pairs will record the depth in feet at increments along each transect. In addition, diver pairs will record the percent of substrate type (reef, boulder, cobble, or sand) and the relief of each substrate (high= greater than 3m, medium= 1-3m, low= less than 1m) for each 5m increment of transect.

c) Habitat Data

(1.) **Depth:** The depth is taken at the 0, 10, 20 and 30m points on the transect line
(2.) **Habitat Relief:** The overall habitat relief is recorded for the previous 5m surveyed at each 5m mark along the transect in the following categories:
  a. Low (< 1 meter height)
  b. medium (1 – 3m)
  c. high (> 3m)
(3.) **Habitat Type:** The habitat type is recorded for the previous 5m at each 5m mark along the transect line using these categories:
  a. Reef any rock substrate that can't be moved
  b. Boulder – rock > 0.5m that can be moved
  c. Cobble - all rock < 0.5m
  d. Sand – substrate fine enough to be able to insert your finger

6. The Data Sheet

It is important that all the data requested on the Abalone Survey Data Sheet be completed (Figure 4). Each data sheet is specific to a pre-established station. If a station cannot be surveyed, note this on the data sheet, and proceed to the next station, using its specific data sheet: do not substitute locations on a given sheet. All data sheets are to be returned to the Data Manager upon return to the main vessel.

a) Data Sheet Entry

(1.) Diver is the person filling out this form
(2.) Buddy is the accompanying diver
(3.) Dive Date use mm/dd/yy
(4.) Block # pre-printed on form
(5.) Grid # pre-printed on form
(6.) Station # pre-printed on form
(7.) Latitude/longitude pre-printed on form
(8.) Transect Heading is the compass course of transect in degrees and is pre-printed on the form
(9.) Orientation is the side of transect you are on when using the "0" to "30" reference direction, circle either L for Left and R for Right
(10.) Abalone Counts are entered in respective 5m sections along transect line
   a. Enter size to mm for first 15 encountered
   b. Enter segment # in which measured abalone are found
      Note: Abs are assumed to be red. If another species is found, put the initial letter of the common name beside the size or tick mark (F – flat, p – pinto, pk= pink).
      Note: Any abalone that appears to be withered, put a "W" after the measurement.
(11.) Depth record depth at "0", "10", "20", and "30" m along the line
(12.) % Relief record relief within 5m segments. Category percentages should total 100%
   a. Low = < 1m
   b. Medium = 1-3m
   c. High = >3m
(13.) % Substrate record substrate type within 5m segments. Category percentages should total 100%
   a. Reef immovable rock
   b. Boulder movable rocks > 0.5m
   c. Cobble all rock < 0.5m
   d. Sand sandy

7. Completion of the Survey

After completion of the fourth transect, the dive team will retrieve the transect line and ascend with all survey gear. After a suitable safety stop, the divers return to the surface and retrieve the surface float and anchor.

8. **Finalizing the Datasheet**

In the Abalone Counts and Measurements section, count the number of abalone by segment and record number in "total abs" box. Dive teams will check each other's completed datasheet for errors, accuracy and legibility and then initial the "checked by" box.

Upon returning to the main vessel, the divers should give the data sheets to the **Data Manager**, who will also check the data sheets for completion.

9. Measuring and Identifying Abalone

a) Measuring Abalone. Abalones are measured by the greatest diameter of the shell that is typically from the edge of the shell behind the spire towards the leading edge of the shell near the pores (Figure 1). Be sure to measure only the shell and not include any attached invertebrates such as barnacles.

b) Abalone Species Identification. There are three species of abalone that occur subtidally at San Miguel Island, red *Haliotis rufescens*; flat, *H. walallensis*; and pinto, *H. kamchatkana assimilis*. Although red abalone is the most common species, the other two are occasionally encountered. Divers must be able to identify these species to insure that counts and measurements for red abalone are accurate during the survey. The following is a brief description of each species:

(1.) Red Abalone *Haliotis rufescens*

a. **Shell** – color is usually brick red (especially along the inside edge of the shell) but is often masked by encrusting organisms.
b. **Open Pores** - three to four
c. **Epipodium** (edges of the foot) – color is black or barred with black and grey color.
d. **Size** - This is the largest abalone species reaching up to 12.3 inches but is usually between seven and nine inches in diameter.

(2.) Pinto Abalone, *H. Kamtchatkana assimilis*

a. **Shell** – color is a green and rust mottling. The shape is oval and dorsal/ventrally deep with a surface marked with prominent ribs. There is a prominent groove that runs along the outside edge of the pores
b. **Open Pores** – four to six pores that are moderately elevated
c. **Epipodium** – color is mottled a pale yellow to dark brown with a pebbly appearing surface and frilly edge
d. **Size** - reaches six inches but is usually smaller

(3.) Flat Abalone, *H. walallensis*

a. **Shell –** color is a brick red and can often be confused with small reds. The shape is oval and dorsal/ventrally flatten with narrow low ribs on the surface of the shell

b. **Open Pores –** four to eight pores

c. **Epipodium –** color is mottled yellowish and brown with a pebbly appearing surface

d. **Size** - to seven inches but is usually less than five

Complete descriptions and pictures can be found in the following literature:

California Abalone. 1986. Peter L. Haaker, Kristine C. Henderson, and David O. Parker. State of California Department of Fish and Game Marine Resources Leaflet No. 11. pp.16.

Guide to Marine Invertebrates Alaska to Baja California. 1994. Daniel W. Gotshall. Sea Challengers. pp.105.

Diver completing data sheet

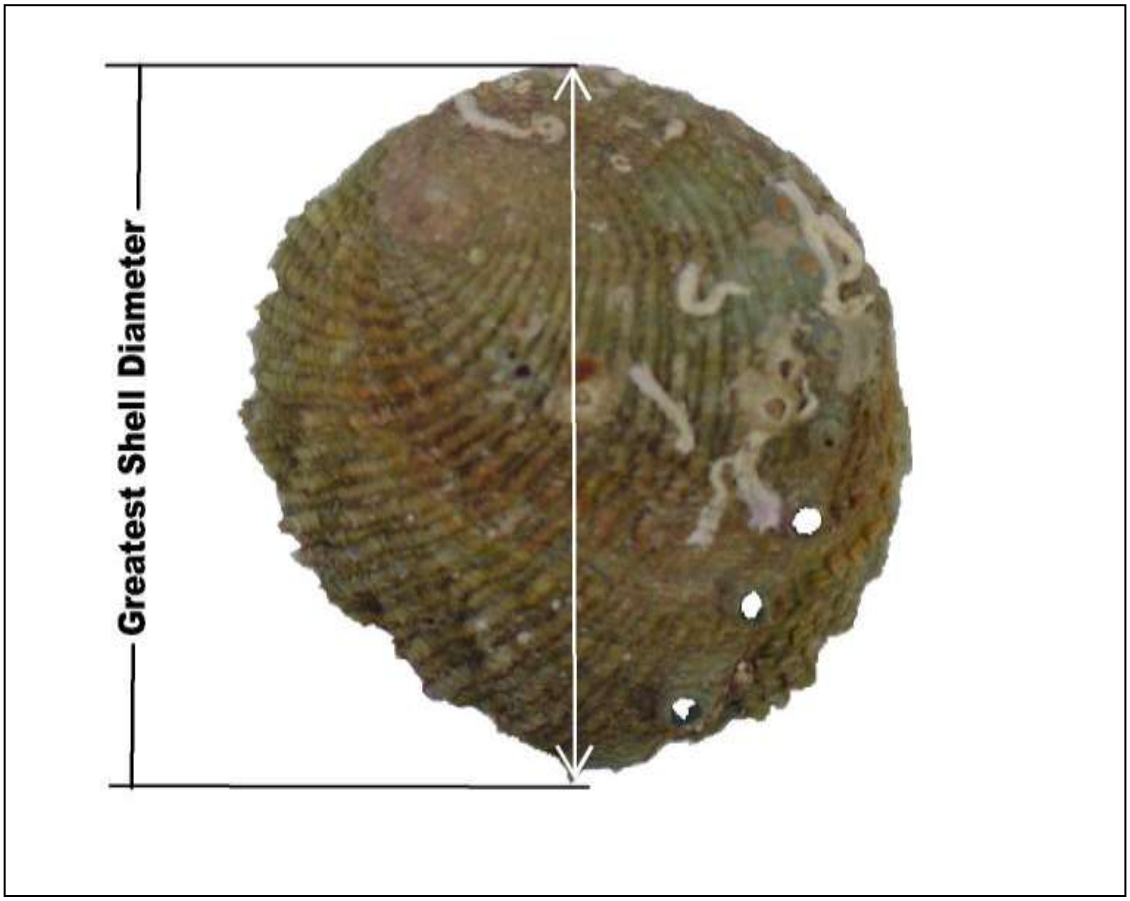


Figure 1. Proper measurement of an abalone.

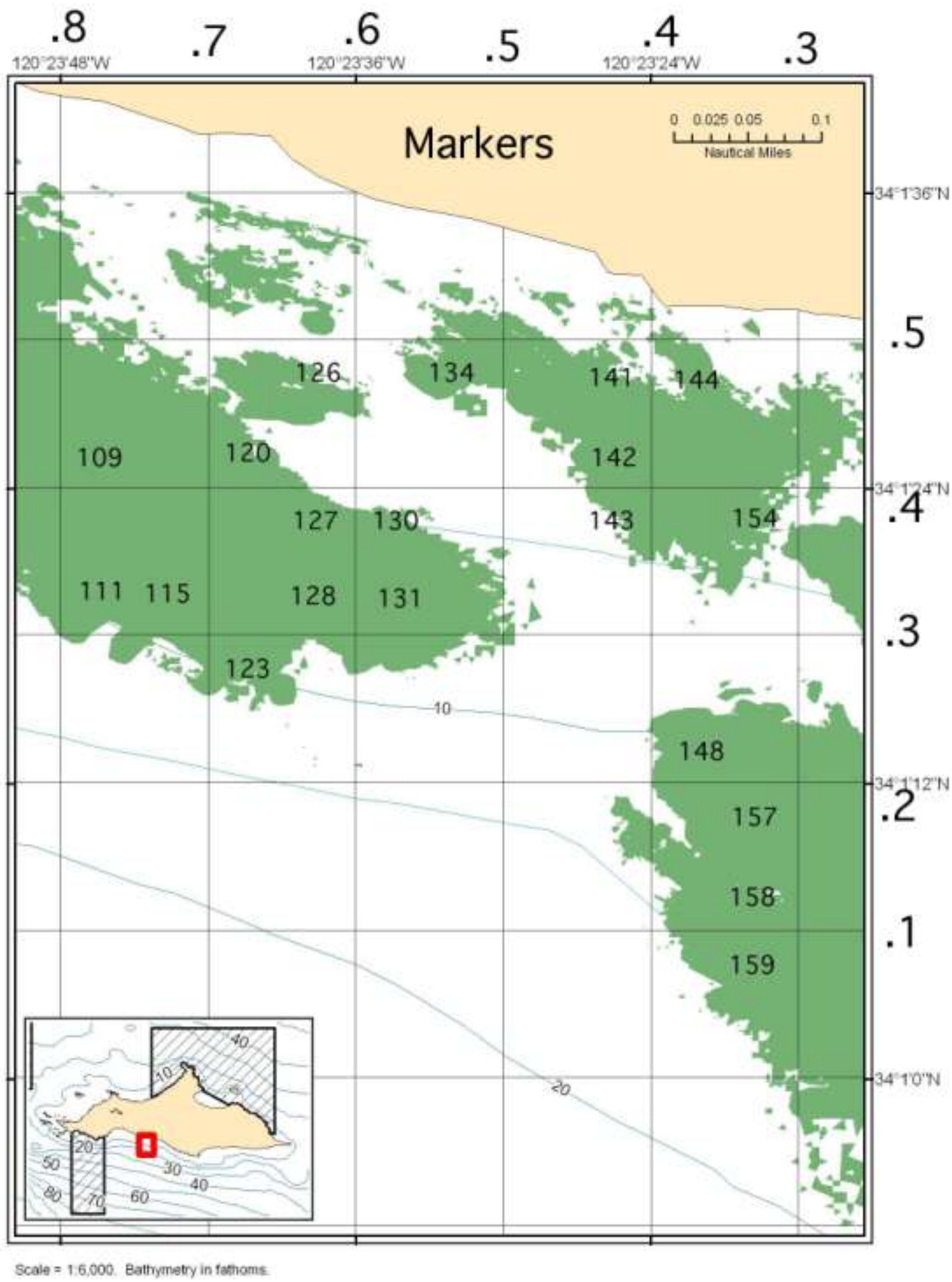


Figure 2. Example of map with grid numbers and survey station numbers for Markers in the Southwest Zone.

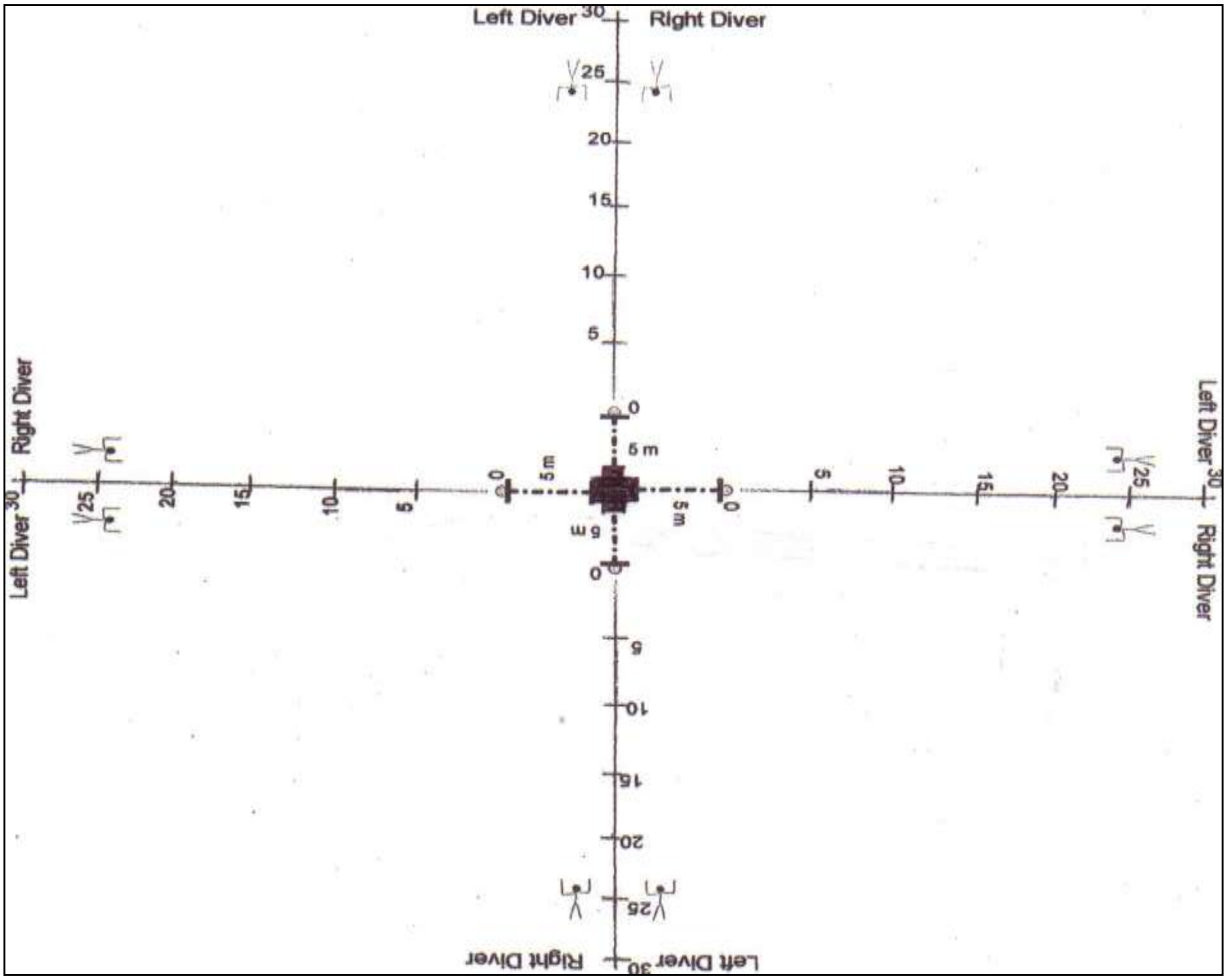


Figure 3. Drawing of a deployed transect viewed from above. Both divers will work side by side along transect.

SAN MIGUEL ISLAND RED ABALONE SURVEY 2009

Block: 690-83	Station: 1	Diver: Moe	Buddy: Joe	Checked By: Joe
Grid: 28	Latitude: 34 01.725	Longitude: 120 26.275		Date: 10/20/09
Transect Heading:	240	Orientation (circle) L R		

Segments:	0-5m (1)	5-10m (2)	10-15m (3)	15-20m (4)	20-25m (5)	25-30m (6)
Count of Total Abalone (use tick mark)	𝍸 ||	||	0	𝍸 ||	0	𝍸 𝍸
	Total: 7	Total: 2	Total: 0	Total: 7	Total: 0	Total: 10
Substrate	% Reef: 90	% Reef: 20	% Reef:	% Reef: 70	% Reef:	% Reef: 100
	% Boulder: 10	% Boulder: 20	% Boulder:	% Boulder: 30	% Boulder: 30	% Boulder:
	% Cobble:	% Cobble: 30	% Cobble: 20	% Cobble:	% Cobble: 60	% Cobble:
	% Sand:	% Sand: 30	% Sand: 80	% Sand:	% Sand: 10	% Sand:
Relief	% Low (<1m): 90	% Low (<1m): 100	% Low (<1m): 100	% Low (<1m): 70	% Low (<1m): 100	% Low (<1m): 80
	% Med (1-3m) 10	% Med (1-3m)	% Med (1-3m)	% Med (1-3m) 30	% Med (1-3m)	% Med (1-3m) 10
	% High (>3m):	% High (>3m):	% High (>3m):	% High (>3m):	% High (>3m):	% High (>3m): 10

Length (mm) of first 15 abs and Segment #															
Segment (1-6)	1	1	1	1	1	1	1	2	2	4	4	4	4	4	4
Length (mm)	166	212	197	156	110	224	175	170	190	254	234	195	205	200	160

Depth @ 0m 25'	Depth @ 10m 20'	Depth @ 20m 23'	Depth @ 30m 18'

Transect Heading:	60	Orientation (circle) L R

Segments:	0-5m (1)	5-10m (2)	10-15m (3)	15-20m (4)	20-25m (5)	25-30m (6)
Count of Total Abalone (use tick mark)						
	Total:	Total:	Total:	Total:	Total:	Total:
Substrate	% Reef:	% Reef:	% Reef:	% Reef:	% Reef:	% Reef:
	% Boulder:	% Boulder:	% Boulder:	% Boulder:	% Boulder:	
	% Cobble:	% Cobble:	% Cobble:	% Cobble:	% Cobble:	% Cobble:
	% Sand:	% Sand:	% Sand:	% Sand:	% Sand:	% Sand:
Relief	% Low (<1m):	% Low (<1m):	% Low (<1m):	% Low (<1m):	% Low (<1m):	% Low (<1m):
	% Med (1-3m)	% Med (1-3m)	% Med (1-3m)	% Med (1-3m)	% Med (1-3m)	% Med (1-3m)
	% High (>3m):	% High (>3m):	% High (>3m):	% High (>3m):	% High (>3m):	% High (>3m):

Segment (1-6)															
Length (mm)															

Depth @ 0m	Depth @ 10m	Depth @ 20m	Depth @ 30m

Figure 4. Example of completed Data Sheet.

APPENDIX I: FEDERAL ANTITRUST ISSUES RELATED TO FISHERMEN'S COOPERATIVE MARKETING ASSOCIATIONS

From Joseph M. Sullivan of Mundt MacGregor L.L.P. - March 2, 2009

A. The antitrust laws of the United States prohibit certain anticompetitive activities. The classic example is price fixing—two or more entities that would otherwise compete on price instead agree to sell their products for the same (and more profitable) price. Such conduct eliminates price competition and is therefore "anticompetitive."

B. A limited exemption to the general prohibition on price fixing and other anticompetitive activities is provided by the federal Fishermen's Collective Marketing Act ("FCMA"), 15 U.S.C. §§ 521-522, for certain activities of qualified fishermen's cooperative marketing associations. To qualify for the FCMA's limited antitrust exemption, an association must meet the following four requirements:

1) Association membership must be limited to "fishermen."

  a) There is no bright-line test of what is a fisherman. Rather, consideration will be given to a member's:

    (i.) Activities;
    (ii.) Degree of vertical integration (i.e., engagement in, or a relationship with parties that are engaged in, processing or marketing of products from the fishery); and
    (iii.) Functions historically performed by fishermen in the area.

  b) A member's processing "on the side" is problematic. However, the type of processing and the extent to which it is historically done by bona fide fishermen in the area must be considered before it can be determined whether the member is or is not a "fisherman" under the FCMA.

    (i.) Another complicating factor, besides a member's own processing, is a member's service as an agent, employee, or contractor for a third-party processor.

  c) One member's failure to qualify as a fisherman can potentially destroy the FCMA antitrust exemption for the entire association.

  d) Avoid even the appearance that the association includes non fishermen as members.

2) Association may deal in product of members and nonmembers, but the value of members' product must be greater than or equal to the value of nonmembers' product.

   a) Sales by association members outside the association could impact the association's ability to meet this requirement and also affect its long term viability.

   b) Product purchased by association members from nonmember sources and marketed through the association counts as nonmember product because it is not produced (that is, harvested) by association members.

3) Association must be operated for the mutual benefit of its members.

4) Association members are limited to one vote or dividends limited to 8% per annum.

C. Activities falling within the FCMA's antitrust exemption:

1) Fishermen "may act together in associations … in collectively catching, producing, preparing for market, processing, handling, and marketing" of "aquatic products." 15 U.S.C. § 521.

   a) Multiple FCMA associations may share a common "marketing agency." 15 U.S.C. § 521.

2) "Marketing" has been defined as "the aggregate of functions involved in transferring title and in moving goods from producer to consumer, including among others buying, selling, storing, transporting, standardizing, financing, risk bearing, and supplying marketing information." Treasure Valley Potato Bargaining Ass'n v. Ore-Ida Foods, Inc., 497 F.2d 203, 215 (9th Cir. 1974).

3) Protected activities include:

   a) Members of an FCMA association agreeing to a price floor below which they will not sell; and

   b) An FCMA association—or two or more FCMA associations acting through a common marketing agency—conducting collective price negotiations on behalf of association members.

D. The FCMA's antitrust exemption is limited. Areas of antitrust risk for FCMA associations include the following:

1) Price agreements.

   a) An FCMA association may not engage in simultaneous price negotiations with two or more buyers if, during the negotiations, the association discloses to Buyer A the price it is attempting to negotiate with Buyer B, or vice versa. In such situations, the association would be acting as an impermissible conduit of price information between buyers.

   b) Members of an FCMA association may not reach agreements on price with non-member competitor fishermen who are not part of another FCMA association. However, when acting as a fish buyer, an FCMA association may post or otherwise freely transmit to the public the price at which it is offering to purchase fish.

2) Transmission of competitively sensitive information.

   a) Competitively sensitive information includes:

      (i.) Price, output or cost data;
      (ii.) Customers or territories; and
      (iii.) Operating plans or future business plans.

   b) The FCMA does not protect transmission of competitively sensitive information by members of an FCMA association to buyers, processors or non-member competitor fishermen. Such information could be used by such entities for anticompetitive purposes. The classic example would be non-member competitor fishermen obtaining the price at which an FCMA association's members intended to sell their product to a particular buyer and then selling their product to that buyer for the same price—thereby contributing to a "fixing" of the price.

   c) Besides direct transmission of competitively sensitive information, FCMA association members also should avoid indirect "price signaling" to buyers, processors or non-member competitor fishermen. This could occur if association members make sales outside the association while the association is negotiating price with a buyer or processor.

3) Collaboration with entities not qualified under the FCMA.

a) FCMA associations may collaborate with entities not qualified under the FCMA, but any such agreements will be evaluated under the full range of antitrust laws and will not be protected by the FCMA's antitrust exemption.

4) Predatory conduct.

a) General test: Is conduct anticompetitive and does it lack a legitimate business justification?

b) Examples: Coercing non-member competitor fishermen to join the association and comply with its members' price agreements; campaigning against a store that sells product of the kind produced by the association's members, but obtained from other sources.

c) Essential facilities doctrine: An entity with an "essential facility" may be under an obligation to make the facility available to its competitors under reasonable circumstances.

5) Member selection.

a) Reasonable conditions on membership in an association are generally permissible.

(i.) Examples: Applicant must qualify as a fisherman, sign membership and marketing agreements, and pay a membership fee. Other legitimate justifications for limiting membership may include an association's limited capacity to handle product and the need for a potential member to produce product meeting the association's quality standards.

b) Denying membership in an association may raise antitrust issues if membership is essential to staying in business and competing with the association's members.

6) Customer selection.

a) In general, an association may sell all its product to one buyer. However, an association's refusal to deal with other buyers may violate antitrust laws if such a refusal is a means to acquire a monopoly, fix prices, or drive out competitors.

7) Undue price enhancement.

a) The FCMA authorizes the Secretary of Commerce to issue cease-anddesist orders to an FCMA association if “such association monopolizes or restrains trade in interstate or foreign commerce to such an extent that the price of any aquatic product is unduly enhanced by reason thereof.” 15 U.S.C. § 522.

APPENDIX J: "MOE"

This is a hypothetical diving trip in the life of a cooperative abalone diver in the re-opened red abalone fishery at San Miguel Island (SMI).

Moe had held an abalone diving permit when the fishery was closed. He has been actively engaged in the activities of the California Abalone Association (CAA) since he had become a diver and became a member of the California Abalone Cooperative (CALAB) when it was formed. Moe has helped with several research projects and has participated in collaborative surveys at SMI in previous years. Along with Moe's commercial abalone fishing experience he has also worked sea urchin and sea cucumbers at SMI. All of this knowledge and experience makes him thoroughly familiar with SMI and provides him intimate knowledge of its reefs, weather, and habitat.

Moe has attended meetings with CDFG at which the Total Allowable Market Catch (TAMC) was established and then cooperative meetings which allocated that harvest to the various areas and divers. He has been fully trained in survey protocol procedures and understands that the allocation for each area was determined by using survey data and diver input.

Moe checks the weather and sees the weather is perfect today for getting to and diving at SMI. The south and west swells are down and the wind is forecast to be 10 knots. His boat is ready to go as he's been harvesting red urchin and sea cucumbers recently.

As Moe prepares to leave the harbor he calls the cooperative phone line that records his abalone trip intentions. This includes: a) name, b) license information, c) harvest blocks or grids he expects to fish, and d) planned return time. This information is recorded and available to CDFG wardens. As Moe motors from the Santa Barbara Harbor he turns on his Scielex GPS tracker (www.scielex.com.au). This device records his position every ten (10) minutes and data from the logger can be downloaded by CDFG wardens if they want to audit his fishing trip positions and provides accurate mapping of catch locations for further refinement of cooperative harvest strategies.

Moe will be diving in the Southwest zone of SMI. No abalone harvest is allowed in Judith Rock Marine Protected Area and the Southeast, Northeast, and Northwest zones are also off-limits. It is estimated that there are one million emergent red abalone at SMI and approximately 680,000, or 70% are in these no-take reserves. Moe and other cooperative divers will harvest 10% of the abalone over 8 inches in the Southwest zone. This is about 3% of the abalone in the harvest area and 1% of the total emergent population at the island.

As Moe Passes Crook Point and enters the fishing zone his tender gets his gear ready. He finds his first assigned zone and the tender sets the anchor. He uses a hookah air system and carries a small mesh bag as well as his abalone bar, a slate, and a pencil. When he's suited up and ready to go the tender pushes a button on the Scielex that records the start time and position of the first dive. Moe descends to the bottom to select the 24 abalone allocated to him in this zone. He swims a preliminary search around the boat and as he moves along the bottom he sees some shorts and a few legal sized abalones. On his slate he notes the character of the bottom and nature of the abalone population at this position.

After his preliminary data collection, during which he discovered some aggregations, he starts to harvest. Following the cooperative harvest plan he can take no more than 30% of the abalone in any aggregation. He measures the largest abalone and selects seven legal sized abalone from a group of 25. In the next group of 15 there are 12 of legal size he harvests only five. Moe and the other divers understand that preserving the aggregations will help ensure successful spawning.

When he gets back on the boat the tender pushes the end button on the Scielex that records the time (about an hour) and boat's position at the end of the dive. Moe's tender weighs, measures and applies a numbered tag to each abalone as soon as they are brought aboard. Moe adds length/weight information and the tag numbers to his logbook entry.

Moe has now harvested half of the abalone assigned to him in this block and decides to move over about 100 meters to another location within the same zone. Before ascending he had noted the size of the groups remaining after harvest and the aggregation's relative position to the boat on his slate. He also noted that there were two areas of rubble reef that contained aggregations of all sizes deep in cracks that were not harvested.

During his rest period between dives Moe transfers the pertinent information from his slate to the logbook and maps the relative positions of habitat and abalone seen on the dive. As he descends again the tender again pushes the begin button on the Scielex. Moe repeats the procedure of his first dive and after an hour or so ascends with another twelve abalone. Again the tender pushed the end button on the Scielex then weighs, measures and applies a numbered tag to each abalone as soon as they are brought aboard. The Moe adds length/weight information and the tag numbers to the logbook entry. He has now harvested the abalone from the zone according to his assignment. While his map of the zone is incomplete, it will provide the next harvest assignment in this zone. Over time a complete picture of the habitat and population within this block will emerge.

If Moe is boarded by CDFG, NPS, CINMS, or Coast Guard fisheries enforcement, they will find all the abalone aboard are tagged and logged. Moe knows if he violates the rules he might lose his special permit to harvest abalone and sea urchin. In fact, if the violation is serious, he would lose his California commercial fishing license which is a prerequisite for any commercial fishing privilege. Without that abalone permit, Moe would also be ineligible for membership in the cooperative.

After lunch Moe and his tender move to another zone. The next zone is an area where the population was estimated to be higher than the first. Moe has been allocated 36 abalone in this area. He again follows the procedure of his previous dives. After two more dives Moe harvests his allotment from the zone. He and his tender go to Tyler Bight and anchor for the night.

On the next day they visit three other micro-blocks and follow all the same procedures. By the end of his two-day trip Moe has harvested 120 abalone from the micro-blocks he was assigned. This equals his individual fishing quota for the year. He has stored the abalone in receiver boxes inside his live well to ensure his abalone will be alive and healthy upon reaching the harbor.

Sunrise at San Miguel Island

As Moe motors home he calls the cooperative Data Coordinator to report his catch and arrival time. This information is also available to CDFG. When he arrives at the Santa Barbara Harbor, Moe may be checked by a CDFG warden. The warden could download his Scielex data to confirm his dive locations, measure and check tagged abalone, and see that all landing paperwork is in order. Paper work and Scielex data are available to CDFG enforcement personnel for audit at any time and the abalone can be tracked through paperwork (FGC 8043 and 8050).

Once in the harbor, this information is also entered into the Trace Register system where the catch data will be recorded and stored and then updated as it travels through the custody chain to include all information on transport and distribution of the abalone. This information is password accessed and available to consumer and CDFG wardens as well as cooperative personnel at any time.

Moe has harvested his allocation but his work is not over. He and his tender must transfer the abalone to the California Abalone Cooperative's live tank station. The cooperative handles all abalone initially. The cooperative broker's sells to consumers and cooperative members help where and when needed. The Saturday Fisherman's Market at Santa Barbara Harbor is a major sales point and each member takes a turn selling his product and talking with the public. They also distribute pamphlets on how to prepare abalone along with an explanation of the fishery regulations and procedures used to ensure sustainability.

The fishery has been planned to extend through the summer (three months). While the harvest of the initially small allocation could occur in a week, the landings are extended through the season by staggering assignments to individual divers to avoid glutting the market and assuring realization of maximum value. The members of the cooperative have agreed to pool all catches and values. This means that they are all paid an agreed price initially and later after the complete allocation is taken and business concluded, any further net profit is equally distributed to the members. In this way Moe does not feel he's missing anything at spots others harvest. He knows he will share in any profit the members of the cooperative realize. He also knows next year, with the increased amount of information collected during this season's harvest, he and other members will be more efficient due to the increased knowledge of abalone beds within the individual micro-blocks.

Moe's work continues throughout the year. All the harvest log and other fishery dependent data will be entered into a data base for storage and future analysis. Moe and other cooperative members will also participate in ongoing monitoring and research projects. Tagging of abalone for growth/movement studies and settlement/recruitment monitoring projects are underway at SMI and elsewhere. These data and fishery independent data, will also be entered and stored in the data management system which will be available to the cooperative, managers and researchers for decisions made using the Decision Tree Assessment Process.

These projects are paid for from monies collected from the fishery and matching grants. As research evolves and questions are answered the information is used to adaptively adjust regulations as necessary. Moe and other members of the cooperative attend shared management meetings with CDFG and academics to discuss the year's abalone monitoring and research plans and assess the need to adjust any regulations or quotas. He also attends regular cooperative meetings to deal with infrastructure and marketing issues.

Moe and the other divers are motivated to do all this because they have a stock in the future of the fishery. They make some money today and if they make good choices they will see their bottom line increase in the future. The members of the cooperative are working to husband the resource and if they transfer a cooperative membership to a new diver they will be transferring the privilege to make a little money, as well as the responsibility to work to sustain the fishery and increase profit. A new member, who now has an investment in the future of the fishery, will work toward that end, as Moe and the others have.

APPENDIX K: GLOSSARY OF TERMS

Adaptive Management	In regard to a marine fishery, means a scientific policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning. Actions shall be designed so that even if they fail, they will provide useful information for future actions. Monitoring and evaluation shall be emphasized so that the interaction of different elements within the system can be better understood.
Aggregation	A group or mass of abalone of the same species living closely together
CAA	California Abalone Association. The Association was founded in 1971 and its mission is "to restore and steward a market abalone fishery in California that utilizes modern management concepts, protects and enhances the resource, and guarantees a sustainable resource for the future. "
CALAB	California Abalone Cooperative. The cooperative will be formed in 2010 and it will "place the health and habitat of the abalone resource above all other considerations and will co-manage an abalone fishery while recognizing the link between stewardship of the resource and a successful cooperative. "
Catch Share	An equal division of TAMC among cooperative members.
CPUE	Catch-per-unit-of-effort. The number of individual animals harvested within a given period of time.
DAP	Designated Access Privileges. An output control whereby an individual fisherman, community, or other entity is granted the privilege to catch a specified portion of the TAC. With this assurance in place, there is no longer an incentive for fishermen to fish harder and faster because each could only catch his or her share of the total. The incentive would then be to catch the full share at a low cost and sell the best quality fish at the highest obtainable price.

GIS	Geographic Information Systems. A system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data. Practitioners also regard the total GIS as including the operating personnel and the data that go into the system.
GPS	Global Positioning System. A worldwide radio-navigation system that was developed by the US Department of Defense. In addition to military purposes it is widely used in marine, terrestrial navigation and location based services.
High-Grading	Harvesting one abalone and then coming across another larger abalone and discarding the first one.
Restricted Access Fishery	A fishery in which the number of persons who may participate, or the number of vessels that may be used in taking a specified species of fish, or the catch allocated to each fishery participant, is limited by statute or regulation.
Sustainable	Continuous replacement of resources, taking into account fluctuations in abundance and environmental variability. Securing the fullest possible range of present and long-term economic, social, and ecological benefits, maintaining biological diversity, and, in the case of fishery management based on maximum sustainable yield, taking in a fishery that does not exceed optimum yield.
TAC	Total Allowable Catch. The total quantity of a species of animals allowed to be harvested from defined areas during a given time period, typically one (1) year.